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6 August 1980

USSR Report

ENERGY

(FOUO 13/80)

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USSR REPORT

ENERGY

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ELECTRIC POWER

REPORTS ON OPERATION OF LOVISA AES PRESENTED AT SEMINAR

Moscow ATOMNAYA ENERGIYA in Russian No 5, May 80 pp 347-348

[Article by V. A. Voznesenskiy: "Operational Experience at the Lovisa AES (Finland)*"]

[Text] Various operational aspects of AES's with VVER-440 reactors were discussed at the seminar: experience in operating the AES equipment and systems, the monitoring of the operation on the part of the authorities, the operational reliability, nondestructive methods of inspecting materials and equipment and radiation safety. In the Soviet reports, as a rule, the results of an operational analysis of many of the assemblies were stated.

A. Palmgren, the director of the Lovisa AES, presented a review of the basic results of the station's operation from the moment it was put into industrial service (from 9 May 77 to 31 May 79). The load factor of the AES amounted to 77.7 percent. During the operational period there were no situations that were dangerous to the staff or to the environment. The emergency shielding was released only once in two years while the station was operating at power. The overall number of equipment malfunctions declined constantly. A comparison with international characteristics carried out in the report shows that the results achieved at the "Lovisa-1" AES are good in all respects.

A detailed analysis of the operation of the main circulating pumps (GTsN's), the steam generators, the control and shielding systems, the automatic devices, the power supply, the loading equipment, pumps, fittings and the circulating system was contained in the reports of S. Merisaari, Ya. Kuyal, Ye. Miyettinen, et al.

The main circulating pumps were manufactured by the "Finatom" firm. After the elimination of defects in the pumps' operation during the start-up and adjustment period (an uneven power draw by the motors, contamination of the seals, etc.) there was not a single case during industrial operation when the station had to be shut down in order to conduct unforeseen inspections. Nevertheless, during rechargings in 1978-1979 damaged bolt connections were discovered in the water walls and covers of the pumps. After elimination of the defects which had been discovered (defects that, in the author's opinion, bore the nature of a "children's disease"), the set-up of the main circulating pumps at the "Lovisa-2" AES proceeded without difficulty.

The horizontal steam generators of Soviet design operated practically without fault. The heat-transfer coefficients during the operational process were kept constant, and under nominal conditions the moisture content of the steam did not exceed 0.15 percent.

No significant difficulties were noted during the operation of the turbines. The greatest problems were associated with corrosion of the pipes and equipment cooled by sea-water. By the summer of 1979, 11 malfunctioning tubes in the condensers were plugged. All sea-water pipes of 100 mm internal diameter and less and some of those with 200-300 mm internal diameters had to be replaced with plastic or rubber-coated pipes. The conclusion was reached that it would be expedient to use titanium in the turbine condenser tubes and in the other heat-exchangers.

The operational experience gained from the main generators is favorable. The generators operated without fault when the load was removed during testing. Despite the complexity and, in the opinion of the speaker, the unconventional design of the voltage generating and regulating equipment, the strict requirements that have been established in Finland were met satisfactorily after a few attempts. The generators are built with lever collars, which causes great difficulty in servicing the brush apparatus. However, thanks to the proper choice of brush pressure and the current density, the generators operate well on the same carbon brushes over the entire time interval between rechargings of the reactor. During two and a half years there were only 10 instances when the generators had to be disconnected from the systems.

Appreciable losses of electric power (approximately 1 percent of the total production) were associated with defects in the fittings, primarily with leaks through the packing glands and the surfaces of the sealing agent. To a considerable degree it was possible to eliminate these defects by means of injecting the packing into the leaking gland through a specially drilled hole.

The overall condition of the pipes in the first and second circuits was good. For example, during a check of the pipes in the main circulating loop (two checked in 1978, two in 1979) not a single defect was discovered that had been formed or had grown larger during operations.

There is a very high degree of automation at the "Lovisa" AES. On the whole, equipment from Western European firms is being employed. The most important functions, however, such as the shielding and control of the reactor, are carried out with the aid of Soviet equipment. The shielding interlock and automation systems operate very reliably. The computer, of

English manufacture, has much to recommend it. In the period from 1 January to 31 October 1977 it was in operation 98.4 percent of the time, and from 1 November 1977 to 31 March 1978 it was in operation 99.7 percent of the time. However, about 300 changes had to be inserted into the programming.

The supervision of operational safety at the AES is entrusted to the Institute for Radiation Safety (T. Eurol) and is founded upon legislation for the utilization of atomic power and upon other normative documents. In contrast to practices adopted in the USSR, almost all of the safety aspects at the AES are controlled by one institution. The institute has five departments: medical, inspection, safety, research and administration. Supervisory activities include monitoring the quality of the operation, the fuel, the transfer of radioactive substances, personnel qualifications, repairs, modernization and accounting. Provisions have also been made for periodic checks and for inspection under emergency conditions.

Both in the USSR and in Finland great importance is attached to the selection of data on operational reliability and their statistical processing and analysis. In Finland this work is carried out by the State Center for Technical Research. Toward this end, maintenance forms are used at the "Lovisa" AES. In order to standardize the information, they are filled out beforehand and require only that a check be placed in the necessary block. The forms are processed in a computer which, on order, will provide information on equipment troubles. During two years of operation, quantitative data has been obtained on malfunction probabilities in the core's emergency cooling system and the intermediate circuit.

The problems involved in the nondestructive testing of materials and equipment at the AES were examined in the reports of S. Khyurulaynen, E. Leklin, V. V. Grebennikov, et al. An ultrasonic method is employed to inspect welded seams in the first sircuit. It was pointed out that the interpretation of the flaw detector's readings is greatly complicated by reflections associated with the seam's geometry. From 100 to 1,000 geometric reflectors are fixed on each flaw discovered. The position of the reflectors must be determined with rather great accuracy (±1 mm). Positive experience was also obtained by the Finnish specialists in the application of an eddy-current method of inspecting tubes in the turbine condensers and the steam generators.

The radiation situation at the AES was discussed in the reports of B. Val'strem, A. Tamminen, L. M. Luzanova, et al. It was noted that the working staff and the population are reliably protected from radiation. The collective radiation dosage for the working staff is 100 Rem/yr. (1 Rem=0.01 J/kg); there are no nonhermetic fuel elements in the core; the amount of tritium released into the environment is about 150 Ci/yr (1 Ci=$3.7 \cdot 10^{10}$ disintegrations per second), while the release of radioactive gases into the atmosphere is four orders of magnitude less than the maximum permissible values.

Topics for further cooperation on VVER problems were planned.

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ELECTRIC POWER

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UNDERGROUND STRUCTURES OF ROGUNSKAYA GES

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 6, Jun 80 pp 3-9

/Article by Engineer L. G. Osadchiy and Candidates of Technical Sciences V. F. Ilyushin and I. S. Bubman: "Progressive Solutions in the Designing of the Underground Structures of the Rogunskaya GES"; passages enclosed in slantlines printed in italics/

/Text/ The Rogunskiy hydraulic development[1] for combined irrigation and power purposes is the uppermost stage of the Vakhsh Cascade and is located 70 km upstream from the Nurekskaya GES.

The installed capacity of the GES with six units is 3.6 million kW, the average annual generation of electric power is 13 billion kWh, the total volume of the reservoir is 13.3 km^3, the effective volume is 8.6 km^3.

Geologically the section of the site is a uniform tectonic block, which is enclosed by the Ionakhskiy and Gulizindanskiy breaks of order II and the Vakhsh plutonic break of order I. The seismicity of the section is 9 points.

The rock--sandstones, aleurolites and argillites of the Lower Cretaceous--outside the weathering zone is notable for high strength properties, regardless of its belonging to one member or another; in a water-saturated state the average value of the compression strength in the monoaxial application of stress reaches 105 MPa for sandstones and 60 MPa for aleurolites and argillites.

In accordance with its physicomechanical and filtration properties depending on the depth of occurrence and the degree of influence on the massif of rock of the processes of weathering and release the entire massif in the vertical cut is conditionally broken down into four zones: I--the zone of heavy weathering and release; II-- the zone of weathering and release; III--the zone of release; IV--the zone of practically unchanged rock.

1. L. G. Osadchiy, R. I. Bakhtiyarov, "The Rogunskiy Hydraulic Development of the Vakhsh River," GIDROTEKHNICHESKOYE STROITEL'STVO, No 4, 1975.

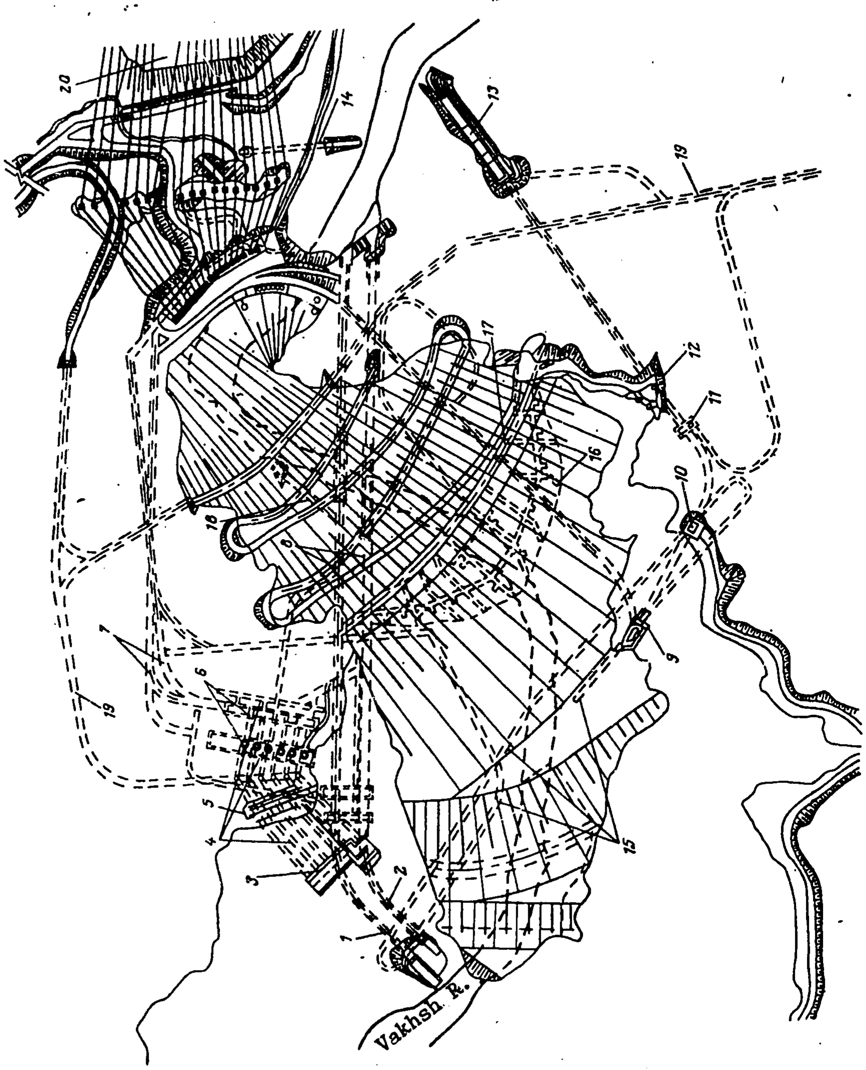

Figure 1. Diagram of the Main Structures of the Rogunskaya GES [Key on following page]

Key to Figure 1. 1, 2--construction tunnels respectively of tiers I and II; 3--water intake; 4--inlet tunnels and turbine water conduit; 5--wells of the emergency and repair gates; 6--building of the GES; 7--transportation tunnel; 8--outlet tunnel; 9--operating spillway with submerged water intakes; 10--well of the repair gate; 11--compartment of the main gates of the spillway; 12--well spillway; 13--terminal structure of the spillway; 14--outlet tunnel on the Obi-Shur saya; 15--tunnels for protecting the bed of salt from erosion; 16--crest of the dam; 17--/omitted/; 18--auxiliary tunnel; 19--transportation tunnel; 20--outdoor distribution system.

The structures of the Rogunskiy hydraulic development include (Figure 1): an earth and rock dam, the structures of the pressure station block with the underground building of the station and an outdoor distribution system, construction tunnels and an operating spillway of the underground type; the structures for protecting the bed of salt from erosion in the base of the dam; the structures of the mud flow protection complex of the Obi-Shur saya; transportation tunnels.

The structures of the underground complex, the total length of the shafts of which comes to 60 km, occupy a special place in the design of the Rogunskaya GES.

Many problems, which were caused by the unique parameters of the structures and the complex natural conditions of the construction site, arose during the designing of the underground structures of the Rogunskaya GES. To solve these problems the necessary scientific research, planning and design work was done, as a result of which new progressive solutions were elaborated and developed, which yield a favorable impact which takes the form of the technical feasibility of solving the problem, the saving of construction materials and labor expenditures, the reduction of the cost and the shortening of the construction period, the increase of the operating reliability of the structures and others.

/Construction Tunnels/. The use in the construction tunnels of gates, which operate under a head of up to 200 m, makes it possible to drop one string (the third tier) of the construction tunnel.

The layout of the construction tunnels from the left bank to the right by the shortest route with a crossing of the river bed in reinforced concrete tubes, as well as the combining of the construction tunnels with the outlet tunnels of the GES (Figure 2) made it possible to shorten the overall length of both tunnels by 1,500 m. Moreover, with such a layout the construction period up to the diversion of the discharge of the river into the first construction tunnel, which at the first stage is constructed until it intersects with the bed, is shortened.

The /combining/ of the outlet tunnels of the operating spillway with the subsurface and surface (well) water intakes (Figure 3). Here the well spillway is connected with the subsurface spillway in a single vertical plane. This arrangement makes it possible to drop the separate independent outlet channel for the well spillway with a length of 500-600 m.

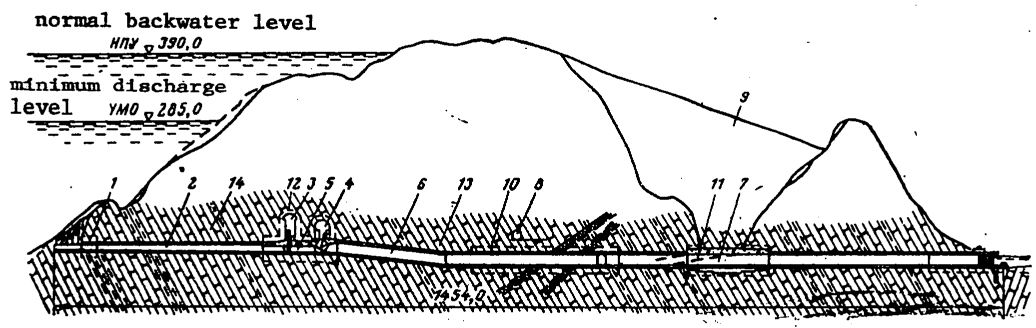

Figure 2. Construction Tunnels of the Rogunskaya GES. 1--inlet portal; 2--pressure section of the tunnel; 3--repair gate block; 4--block of emergency repair and main gates; 5--intercompartment section; 6--free section of the tunnel; 7--section of bed crossing; 8--transportation tunnel; 9--dam; 10--cementing of rock; 11--auxiliary tunnel; 12--sandstones; 13--aleurolites

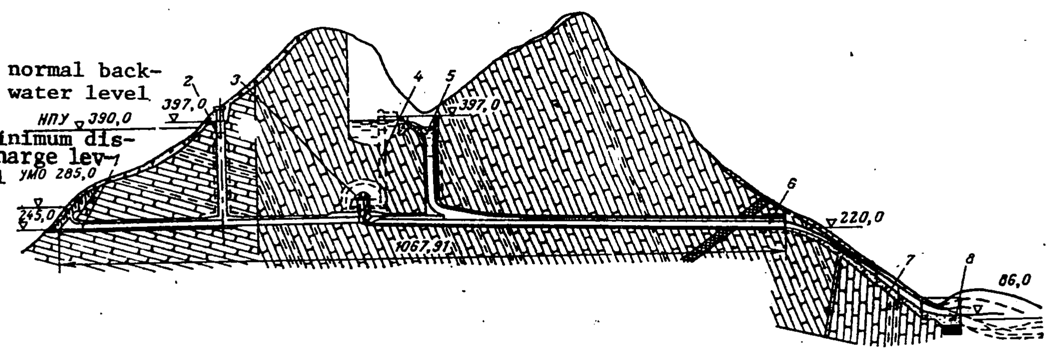

Figure 3. Operating Spillways of the Rogunskaya GES. 1--inlet head; 2--well of the repair gate; 3--compartment of the emergency repair and main gates; 4--aeration and inspection well; 5--well spillway; 6--outlet portal; 7--terminal structure; 8--reinforced concrete anchors

The /terminal structure/ of the outlet channel of the operating spillway (Figure 3). The outlet channel of the operating spillway is situated in a plane with respect to the bed at an angle of approximately 90°. In order to eliminate the erosion of the opposite bank of the narrow river canyon and the flooding of the building of the GES the terminal structure of the spillway is designed in the form of a magnetostep springboard-banking, which ensures the turning of the stream in a plane at an angle of about 50° with its direction along the bed, as well as a considerable reduction of the area discharge.

/Well spillway/. The normally vertical shaft of the well spillway tapers downward, for the purpose of providing positive pressures on its walls. But here in the section of the connection of the neck of the well with the bend, especially under the conditions of the noncoincidence of the direction of approach of the water to the funnel-shaped intake of the well spillway with the axis of the outlet channel, and with discharges less than the rated discharge a whirling of the water usually forms, which is accompanied by the local gushing of the stream, increased surging of the pressure and other negative effects. Moreover, the driving and concreting of the well of varying diameter are complicated.

In the Rogunskiy spillway the shaft of the well and its bend have the same diameter. A local narrowing, the area of which is about 30 percent of the section of the shaft of the well and ensures the passage of the rated discharge, as well as the operation of the well entirely or partially in the pressure mode, was made at the bottom of the shaft of the well (Figure 3). The local narrowing forms a compact current, which retains its form when passing through the bend by means of centrifugal forces.

The /baffle plate/ beyond the outlet portals of the construction tunnels is being built by the "wall in the ground" method. The depth of erosion beyond the outlet portals of the construction tunnel according to the results of model studies reaches 11 m. In connection with the fact that the terminal sections of the construction tunnels are connected with the outlet tunnels of the GES and their outlet portals are permanent structures, the installation of a solid deep plate by the "wall in the ground" method with the use of an SVD-500 unit is envisaged for protecting the latter from erosion.

The /baffle cut-off/ beyond the outlet portal of the auxiliary tunnel of tier I. The depth of erosion of the river bed beyond the outlet portal of the auxiliary tunnel of tier I reaches 15 m. The making of a conventional (concrete and reinforced concrete) baffle cut-off of the indicated depth presents great difficulties. Therefore, the design of the anchor-cementing cut-off, which is several rows of anchors, which have been installed at the base of the portal up to levels lower than the anticipated depth of erosion with the subsequent cementing of the rock, is used at the outlet portal of this tunnel. The experience of using the construction tunnels of the Nurekskaya GES with such a baffle design at the outlet portals revealed positive results.

The /drain lining/, which is attached to the rock. A lining 40 cm thick is used on the pressure sections of the construction tunnel. The pressure of the ground water on the lining is reduced by bore hole drainage, while the residual pressure is transferred through the anchors to the rock.

The /aeration/ of the boundary layer in the free sections of the tunnels. Groove-aerators with a recess are being constructed in the construction tunnels and operating spillway for the purpose of protecting the concrete surfaces of the lining from cavitation at the end of the sections with steel linings, and in the operating spillway also beyond the outlet portals. Owing to the presence of recesses the stream of water falls off the lining. Air enters the zone of reduced pressure and air cushions or an aerated layer of water, which protect the concrete surfaces of the spillways from cavitation, form under the ceiling.

The /lining of the race/ of the spillway tunnels. The experience of operating the spillway, and particularly the construction, tunnels shows that the destruction of the protective layer of concrete (which is usually taken according to the standards to be 7-10 cm thick) and the baring of the reinforcement take place under the effect of sediments and cavitation. The bared reinforcement increases the resistance to the stream, intensifies its turbulence which leads to an increase of the dynamic loads on the lining, which causes the destruction of the reinforcement itself and the concrete behind it. For the purpose of eliminating (or lessening) this effect in the spillway tunnels of the Rogunskaya GES the thickness of the protective layer in the race of the lining is taken to be equal to 50 cm.

The /vacuum drain/ in the free sections of the spillway tunnels. A design with drain outlets, which are located below the level of the water in the tunnel and are connected with the air, is used to increase the effectiveness of the operation of the drain in the indicated sections of the tunnels; there are recesses in the lining before the outlets. When water flows through the tunnel, a discharged space is formed beyond the recesses, which ensures the inflow of the ground water, which enters the drains and collecting mains. With the inadequate discharge of ground water and the operation of the drain outlet with a below standard section air enters the drain outlet through the pipe. Here the section of the air tube is chosen so that the drop in pressure beyond the stream-directing recesses would not reach vapor pressure, owing to which the formation of cavitation effects in the section of the drain outlet is precluded.

The described drain design is envisaged in the construction tunnels of tiers I and II with a length of 530 m. Owing to this an additional decrease of the pressure of the ground water on the lining is obtained and as a result of which a reduction of the consumption of reinforcement is obtained.

The /supports/ of the passages under the crane. In the compartments of the underground machinery of the gates of the spillway tunnels supports of the passages under the crane are used, which include bearing (made from reinforcing steel) rods, which are fastened at the top, and are placed in holes, which have been bored in the rock and have been made monolithic with it by its bottom, while at the top of the holes the rods are separated from the rock by a thin layer (for example, polyethylene film) of anti-adhesive material. The transfer of the strains to deep undestroyed zones of the massif is achieved by this.

/Water intake of the GES/. The water intake of the GES--a subsurface, submerged intake of the tower type with a height of 50 m--is situated 5 m above the minimum discharge level of the reservoir. A link with the shore is achieved by a ramp. The velocity of the water at the gratings is taken to be equal to 0.42 m/sec. Permanent units for cleaning the gratings are not envisaged. The gratings are lifted and cleaned when the reservoir drops to the minimum discharge level. Lengthwise the water intake is broken into three sections, to which two delivery tunnels of the GES each are connected. For the purpose of starting the primary units in the case of low levels the right-hand section has been lowered by 20 m. Holes, which ensure the overflow of water between the sections in case of the uneven fouling of the gratings, have been made in the separating walls between the sections for the purpose of increasing the reliability of operation of the water intake by means of the improvement of the water regime.

The /delivery/ tunnels of the GES (Figure 4). Six strings of delivery tunnels with an inside diameter of 7.5 m and an average length of 240 m run from the water intake. The number of tunnels is taken to be equal to the number of units due to the fact that the length of the intake channel is small (on the average the length of one string of the delivery tunnel and the turbine water conduit is 440 m), and the construction of the underground spills involves great complications and expenditures on the construction of the assembly compartments and their subsequent covering with concrete. The tunnels are laid out in a plane almost parallel to each other; the width of the rock pillars between the tunnels is 12 m. The tunnels have two types of linings. In the section up to the compartments of the gates the lining is made from reinforced concrete of type 200 with a thickness of 0.5 m with the cementing of the rock at a depth of 5 m. In the section between the compartments of the gates and the turbine water conduits there is a combined lining, which consists of an outer concrete ring 0.5 m thick and an inner steel casing 20 mm thick. The steel casing is used in connection with the proximity of the dry inspection tunnel above the vertical bends of the tunnels which turn into the turbine conduits.

The /turbine water conduits/ (Figure 4) with a diameter of 7 m have a combined lining with an outer concrete ring made from cast concrete 50 cm thick and an inner steel casing. The cementing of the rock around the water conduits is not envisaged. The use of cast concrete will make it possible to carry out the high quality filling of the space behind the pipe and to reduce the labor expenditures.

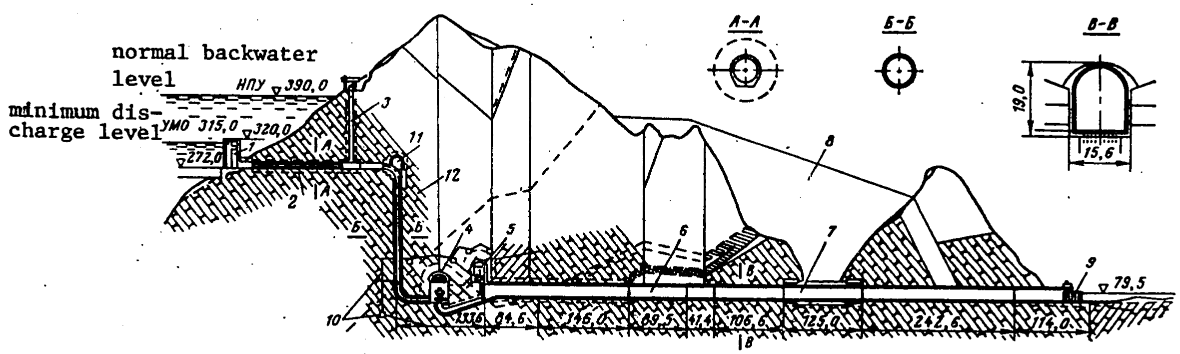

Figure 4. Structures of the Pressure Station Block of the Rogunskaya GES. 1--water intake of the GES; 2--emergency repair gates; 3--wells of the emergency repair gates; 4--machine room; 5--compartment of the transformers and gates; 6--free outlet tunnels of the GES; 7--crossing of the bed; 8--dam; 9--outlet head; 10--tunnels and holes of general drainage; 11--installation gallery above the turbine water conduit; 12--sandstones

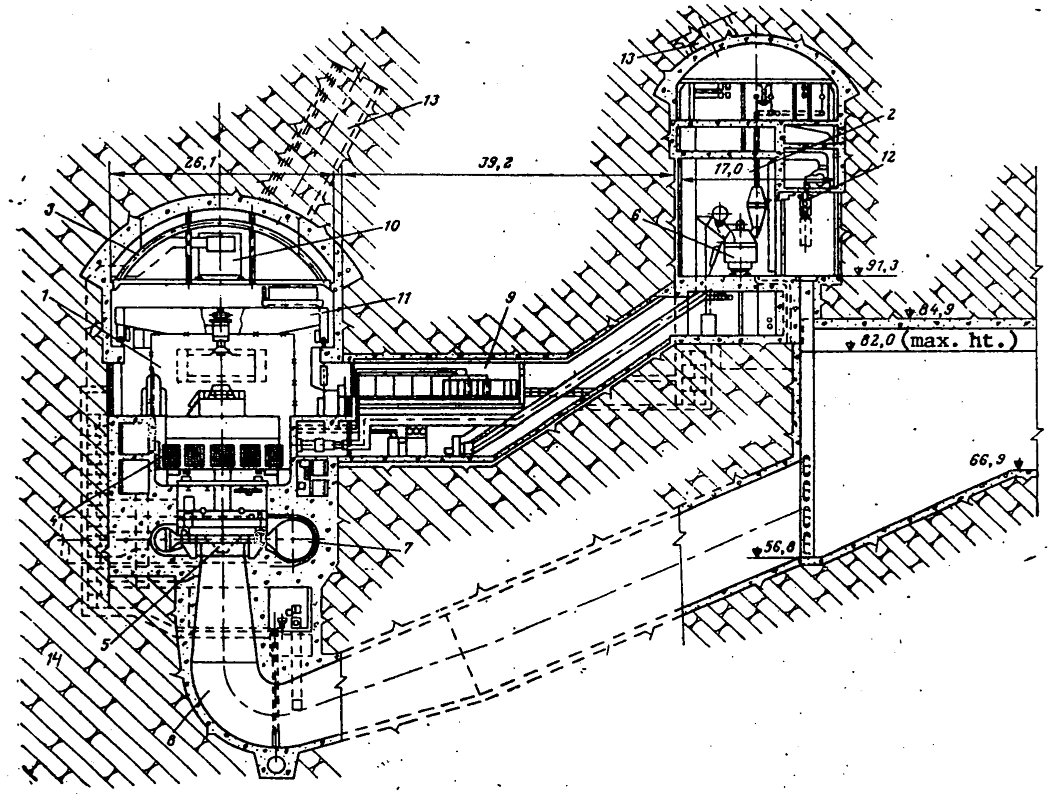

Figure 5. Underground Building of the Station of the Rogunskaya GES. 1--machine room; 2--transformer compartment; 3--protective arch; 4--generator; 5--turbine; 6--transformer; 7--steel reinforced concrete volute chamber; 8--suction pipes; 9--tunnels of connecting wires; 10--air conditioner; 11--overhead crane; 12--monorail car; 13--exhaust shaft; 14--sandstones

The /hydroelectric power station/ was designed with the main arrangement of the underground building of the station. This made it possible to eliminate the intersection of the techtonic break by the delivery tunnels, to locate all the delivery structures in a single techtonic block and to increase the operating reliability of the entire complex of the GES. Moreover, such an arrangement reduces the expenditure of steel on the lining of the delivery water conduits.

The /underground building of the GES/ (Figure 5) in the design is worked out in a two-room arrangement (the machine room and the transformer room). By means of the optimum alinement of both rooms with respect to each other in the pillar between them the stresses were reduced by 30-40 percent. Accordingly more efficient design solutions were used, which on the whole resulted in a substantial reduction of the amount of work and in a saving.

The roof of the shaft of the machine room is strengthened by a reinforced concrete arch with a curve thickness of 1.5 m. The lining of the walls between the arch and the beams under the crane is erected from reinforced concrete 1 m thick and is made monolithic with the arch and the beam under the crane. Within the range of the columns under the crane the walls have an equalizing lining 0.2 m thick, which is anchored to the rock. The roof and the walls of the shaft are strengthened with /deep prestressed anchors/. The support made from prestressed anchors makes it possible to create around the shaft a compressed zone, which prevents the occurrence of strains and involves the rock in active work immediately after the tightening of the anchors.

The transformer room has a design of the lining of the arch and walls, which is similar to the machine room, but with a smaller thickness.

/Strengthening of the pillar between the tunnels with bolts/. The machine room and the transformer room of the building of the GES are interconnected by six tunnels of the connecting leads, which are separated from each other by rock pillars. It was established that given the dimensions, which were used in the design, of the rock pillars between the tunnels of the connecting leads, stresses which exceed the estimated resistance of the rock massif arise in them. In this connection it was recommended to increase the thickness of the reinforced concrete lining of the tunnels of the connecting leads. But in this case the width of the pillars is decreased. In this connection the strengthening of the rock pillars between the tunnels of the connecting leads with steel bolts is stipulated in the plan.

/Antifiltration and drainage/ measures in the section of the station building. Owing to the fact that the building of the GES is located in the head race of the dam with a maximum burying below the normal backwater level of the reservoir of up to 350 m, special drainage and antifiltration measures, which consist of a general drainage screen, the deep cementing of the rock, a gutter drain and decorative walls and ceilings, are envisaged around the compartments of the building of the GES (Figure 4). These measures make it possible to intercept as much as possible the filtration stream and to reduce the pressure of the ground water on the linings. The negligible filtration discharge, which has seeped into the compartments of the station building through the drainage screen and the deep cementing, will run off through the drainage ceilings and linings of the walls into the drainage system of drain water and will be discharged into the tail race or the pump houses for the discharge of drain water. Antifiltration cementing of the rock to a depth of 15 m around the compartments is envisaged on the downstream side of the drainage screen and abuts directly on the linings. Owing to cementing the cracks, which were not intercepted by the general drainage holes, and the zones of greater fracturing in the massif will be eliminated. Owing to the stipulated measures the residual pressure of the ground water on the lining of the compartments of the building of the GES is, according to estimates and studies, not more than 0.1 MPa, while the influx of ground water into the general drainage system with a filtration coefficient of the main massif of 0.05 m/day is expected to be 230 l/sec.

A number of technical solutions, which are notable for novelty and progressiveness, are used /in the plan of the organization of construction/ of the underground complex, the main characteristics of which are cited in Table 1.

Table 1

Amount of Underground Work at the Construction Site of the Rogunskaya GES

Indicators	Total	Main structures: construction tunnels	pressure station block	transportation tunnels
Rock breaking, thousands of m^3.	5322	1121	1387	1569
Structural concrete and reinforced concrete, thousands of m^3.	1535	353	372	361
Wind up operation, thousands of m^3				
backfilling of shafts.	186	135	2	9
concrete of plugs.	355	159	67	34
Number of shafts.	294	44	120	20
Length of shafts, km.	63.7	8.9	17.2	13.8
Cost of construction and installation work, millions of rubles.	308.4	65.3	78.0	73.0

The composition of the general plan with the use of /spiral motor transport tunnels/.

The question of the choice of the optimum version of the composition, which combines deep shafts of the wells of the cemented drifts of the dam (H = 300 m) and spiral transportation tunnels, was made for the following main reasons: the guaranteed meeting of the directive deadlines of construction of the GES in connection with the presence of approaches at different levels: the simplification of the general transport arrangement of the hydaulic development for the period of its construction and operation; the creation of a unified system of water drainage and especially slurry removal during the performance of cementing operations on the dam.

The /use of auxiliary drifts/. To ensure the successful and safe drilling at the preset high rate of large-span full-section shafts (the upper tier of the construction tunnels, the high water spillway, the compartments of the machine room and transformer room) it was planned to drill in advance above the indicated main structures (or their parts) special auxiliary shafts, which have the following purposes: prospecting and the more accurate definition of the geological engineering conditions on the route; the assurance of the performance of the preliminary strengthening of the rock on the sections of ruptured zones by means of cementing mortars or prestressed anchors; the provision of ventilation conditions; the laying of the main pipelines; the construction of emergency exits; the organization of drainage measures; the building of accesses for the period of constant operation.

It should be noted that auxiliary shafts, which improve the organization and performance of the work, are used extensively in the plans and practice of domestic and foreign tunnel construction, for example, the Abakan-Tayshet and the Baykal-Amur Main Rail Line (USSR), between Hokkaido and Honshu islands (Japan) and others. The time for performing the underground work is cited in Table 2.

The values of the rates, which are cited in the table, conform to the promising nature of the construction; they exceed the present achieved values by 40-50 percent for the majority of major domestic construction projects, for example, the Nurekskaya and Charvakskaya GES's; they exceed by 15-20 percent the values of the standard rates.

The /use of sets of highly productive self-propelled equipment/ in combination with maneuverable and economical heavy motor transport is a modern progressive organizational and technical solution. This is convincing attested by the effective experience of the extensive use of the indicated sets in the practice of domestic and foreign underground construction, for example: Abakan-Tayshet, the Baykal-Amur Main Rail Line, the Nurekskaya, Charvakskaya, Chirkeyskaya, Khantayskaya and Kolymskaya GES's (USSR), the (Sekkingen) pumped-storage electric power station (FRG), the Portage Mountain hydroelectric power station (Canada), the Churchill Falls hydroelectric power station (Canada), the KOPS hydroelectric power station (Austria), the (Pocote) hydroelectric power station (Portugal) and the Tumut hydroelectric power station (Australia).

Table 2

Rate of Performance of Underground Work at the Construction Site of the Rogunskaya GES

Types of work	Rate of working (m/month) for different sections, m^2		
	20	20-60	<60
Horizontal tunnels			
Full-section tunneling.	80	70	50
Tunneling by means of the lower bench:			
section under the arch	--	--	50
lower bench.	--	--	80
Concreting of walls and arch.	80	70	50
Concreting of race.	200	175	150
Sloping tunnels			
Full-section tunneling.	80	70	40

/Preliminary strengthening/ of the ruptured rock in the zones of breaks and of the interface with them with the use of cementing mortars (cementing, chemicalization), prestressed anchors, the combination of cementing mortars and prestressed anchors was used to provide the driving of tunnels of large sections with a solid face under difficult geological engineering conditions.

The driving of the tunnel under the cross section of the Vakhsh river bed was worked out by the use of freezing in order to back the measures on the erosion protection of the bed of salt, which occurs at the base of the dam.

The drilling and blasting method of working the rock, which was adopted in the engineering plan, with the use of its most modern version--/contour blasting/--makes it possible to ensure the closest approximation of the actual contour of the rock breaking to its planned profile and at the same time to reduce to a minimum the boundary destructive effect of the energy of the explosives, due to the screening effect of prefissuring.

It should be noted, however, that the extensive adoption and effective use of contour blasting require the working out of a large number of organizational and technical measures, the main ones of which are as follows:

the elaboration and approval of scientifically sound standards of excesses and shortages of rock breaking for their inclusion in the Construction Norms and Regulations and the Regional Unified Unit Cost Rates;

the assurance of the industrial assimilation and output of the necessary list of firing devices and explosives of low blast effect and a dispersed structure of the charge (like Gurit);

the assurance of the industrial assimilation and output in the necessary quantity of drilling equipment and installation and ancillary equipment, which achieve with high precision (±1-1.5°) the directional drilling of the blast holes and bore holes.

On the basis of the diversity of geological engineering conditions, the layout and design decisions and the engineering diagrams of the tunneling, the following advanced forms and types of /temporary strengthening/ were used: sprayed concrete in combination with reinforced concrete anchors, protective reinforced concrete timbering, which is erected by the Bernold method.

The driving of all the /vertical shafts/ is planned with the use of the /headframeless/ method in two stages:

the driving of guide shafts--small-section chutes (2 X 2 m) from the bottom up by means of mechanized units like the KPV and KPN;

the enlargement of the dimensions of the break to the planned sections from the top down with the use of the previously driven guide chute for the gravity transportation of the blasted rock to the lower developed horizon. With this technology it is necessary for the sloping shafts to have an angle of slope of not less than 45°. The indicated solution makes it possible to discard the construction and operation of bulky mining units, to decrease the cost and labor expenditures and to increase the rate of construction and work safety.

The erection of the linings, which were worked out structurally with the use of metal shells, as practice has shown, is solved in the most technologically effective way with the use of a /cast concrete mix/ (OK-18-22), which makes it possible with the minimum clearance beyond the pipe to ensure the high quality of concreting of the horizontal, sloping and vertical shafts.

The progressive solutions of the /mechanization/ of the main types of operations involve the use of advanced highly productive tunneling equipment of domestic make, both which is being series produced (in large or small series) by industry and which has undergone state tests, is being prepared for industrial assimilation and is cited below.

The /drilling/ of a set of bore holes of the face and for the installation of anchors of temporary support is performed by SBU-2k self-propelled drilling units or by rigs like the 3BK-5D, which are equipped with three PK-75 or PK-60 heavy-duty hammers. Self-propelled drilling frames of the modular type, which are equipped with 6-12 hammer drills like the PK-75 on the hydraulic arms of the manipulators, are used for large-section shafts.

The 3BK-5D rig performs work in a semi-automatic mode of drilling of the bore holes with a depth of up to 4 m with the assurance of the parallel transfer of the set initial direction, which is most important for contour blasting. One man attends the rig. Self-propulsion and the presence of a self-contained diesel engine make it possible to use the unit in several nearby shafts.

The /loading/ of the blasted rock is planned by heavy-duty machines of continuous (PNB-3D, PNB-4D) and cyclic operation (EO-5144 and EO-2501 excavators).

The PNB-3D and PNB-4D rock loaders are used mainly in the shafts with a section up to 60 m^2, that is, in all the adits, the conveyor tunnels, the cementing, drainage and auxiliary drifts, the excavators are used in the compartments, in the transportation and construction tunnels and on the lower benches of all the shafts.

The /transportation/ of the blasted rock from the face to the dump is planned by dump trucks mainly like the MoAZ-6401 and MoAZ-6411.

The MoAZ-6401 (6411) dump truck is the most improved underground domestic large capacity (20 tons) vehicle with relatively small dimensions, which is equipped with a dual liquid and catalytic gas-purification system, as well as a backup steering system for the performance of a shuttle mode of movement (model 6411).

The preparation of the /concrete mix/ of the composition and consistency stipulated by the plan is carried out centrally at the concrete plant. Its /delivery/ to the site of pouring in the tunnels is accomplished in mixer trucks like the SB-69 and S-1036, which eliminate separation and losses of the concrete mix during transporting. The delivery of the concrete mix to the space beyond the concrete form is being done through concrete carrying pipes by means of a pneumatic concrete pourer like the PBU-800 or PBU-500, which provide a technical productivity respectively of 15 and 10 m^3/hr. The obtaining of the planned form of the tunnels inside and the achievement of the required properties of the surface of the linings are ensured by the use of various mechanized centering units, for example, the TBU-82.

The question of the mechanization not only of individual operations, but also of the entire tunneling cycle as a whole, that is, the complete mechanization of the tunneling operations, is very important.

Conclusions. The used progressive solutions ensured an increase of the main technical and economic indicators of the construction of the underground complex of the Rogunskaya GES as compared with other facilities, particularly the underground complex of the Nurekskaya GES, which is clearly seen from the data of Table 3.

According to the engineering plan of the organization of the construction of the underground complex of the Rogunskaya GES a reduction of the materials-output ratio by 30 percent, a decrease of the labor expenditures by 10 percent, a decrease of the adjusted cost by 5 percent and an increase of the directive rate by 30 percent were achieved.

Table 3

Comparative Table of the Main Technical and Economic Indicators of the Underground Complex of the Rogunskaya and Nurekskaya GES's

Indicators	Rogunskaya GES	Nurekskaya GES
Amount of rock breaking, thousands of m^3	5321.9	2473
Amount of structural concrete, thousands of m^3	1534.5	1005
Volume of concrete of plugs, thousands of m^3	355.1	85
Length of underground shafts, km	63.7	32.0
Cost of underground complex, millions of rubles	308.4	115.0
Annual output, thousands of rubles/person	13.9	12.0
Directive rate of construction, m/month:		
upper tier	50	35
lower bench	80	60
Materials-output ratio (coefficient of the filling of linings with concrete), percent	28.3	40.5
Labor expenditures, man-days/m^3:		
finished structure	0.97	1.05
rock breaking	0.37	0.40
concrete	0.60	0.65
Adjusted cost of 1 m^3 of finished underground structure, rubles	52.4	54.7
Indicators of peak year		
Number of workers	4100	692
Amount of rock breaking, thousands of m^3	1132.0	139.4
Volume of concrete, thousands of m^3	247.4	94.6
Number of faces	78	19

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EMERGENCY SPILLWAY GATES OF NUREKSKAYA GES

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 6, Jun 80 pp 9-12

/Article by Engineers F. I. Gurtovnik, S. V. Shutenkov and A. K. Mel'nikov: "Construction of the Main Gate Block of the Subsurface Emergency Spillway of the Nurekskaya GES"/

/Text/ The subsurface emergency spillway of the Nurekskaya GES is designed for the release of flood waters at up to 2,000 m^3/sec when the reservoir is full during the period of operation of the hydraulic development, as well as for the release of construction discharges during the period of the final stage of construction of the main structures /1/.

The spillway is a U-shaped tunnel with a section of 90-115 m^2 and a length of 1,337 m with an intake submerged 100 m below the normal backwater level of the reservoir (Figure 1).

The repair gate block, which consists of a single-span chamber of the gate with crossover sections, a well, through which the gate is removed to the unfloodable surface of the ground, and an open compartment of the hoisting mechanisms of the gate, is located in the initial section of the tunnel at a distance of 120 m from the intake. The block of the emergency and main (working) gates, after which comes the free section of the tunnel with a length of 900 m, is located 103 m down from the repair gate block. The terminal water discharge structure is located beyond the outlet portal of the tunnel.

The block of the emergency and main gates includes the two-span chamber of the gates with crossover sections, the well of the emergency gates, the compartments of the hydraulic hoists of the seal and the crank mechanisms of the main gates, as well as two separate underground compartments of the hoisting mechanisms, which are connected with the surface of the ground by a loading tunnel (Figure 2).

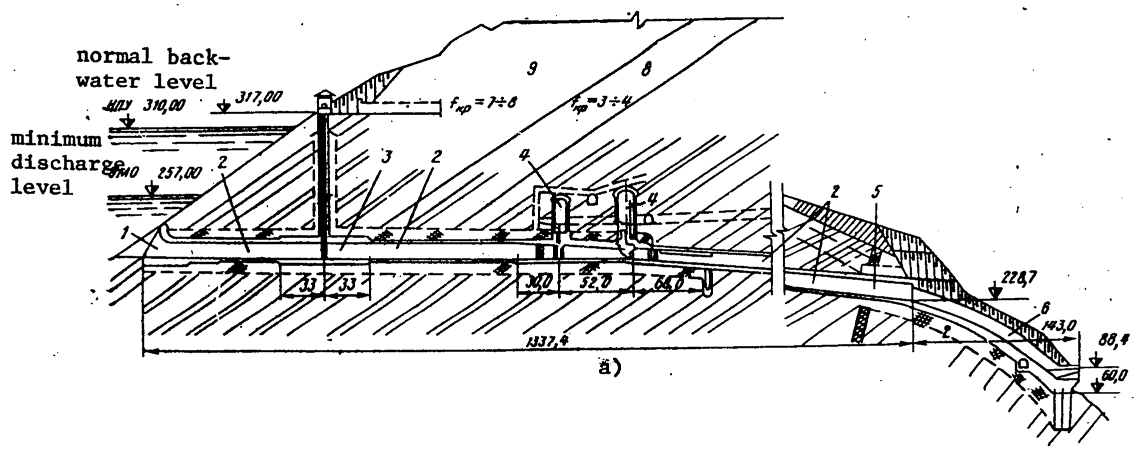

Figure 1. Emergency Spillway With a Subsurface Water Intake of the Nurekskaya GES. a--longitudinal section; b--cross section of the tunnel /omitted in original/; 1--intake; 2--tunnel; 3--repair gate block; 4--block of emergency and main gates; 5--outlet portal; 6--terminal structure

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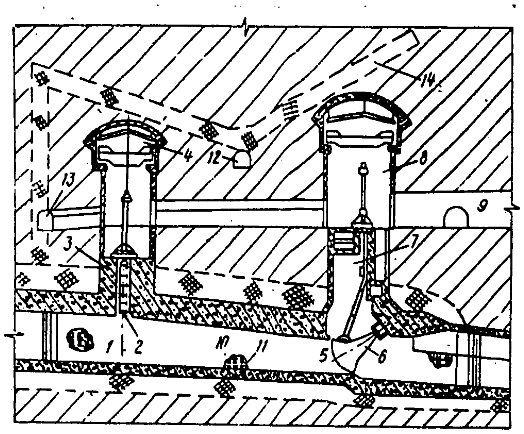

Figure 2. Block of Emergency and Main Gates. 1--chamber of emergency gates; 2--emergency gate; 3--well of emergency gate; 4--compartment of hoisting mechanisms of the emergency gates; 5--chamber of main gate; 6--main gate; 7--compartment of hydraulic hoists of the seal and crank mechanisms; 8--compartment of hoisting mechanisms of the main gate; 9--loading tunnel; 10--section between gates; 11--metal lining; 12--cementing passage; 13--drainage tunnel; 14--cement screen

Two emergency flat track gates measuring 3.5 X 9.0 X 120 m and two main segmented gates measuring 5 X 6 X 110 m are located in the chamber of the gates. The maneuvering of the gates is carried out by hydraulic hoists, and the flat gates are intended only for the emergency shutting of the tunnel even when lowered into running water, while it is possible to operate the main segmented gates with partial openings of the passages, that is, to regulate the flows being released. The well of the emergency gates is intended for the housing of the gates after their removal from the stream. The well is separated from the operating compartment of the hoisting mechanisms by special hermetically sealed covers. The compartments of the hydraulic hoists of the seal and the crank mechanisms are intended for the housing of the equipment which ensures the operation of the main gates.

Two installation overhead cranes with a lifting capacity of 50 tons each for the emergency compartment and of 100 tons each for the main compartment, as well as two hydraulic hoists and the oil-pressure and electrical equipment, which is connected with them, are located in each of the compartments of the hoisting mechanisms of the gates /2, 3/.

The plane dimensions of the compartment of the hoisting mechanisms of the main gate are 45.0 X 13.8 m with a height of 25 m, the plane dimensions of the compartments of the hydraulic hoists of the seal and the crank mechanisms are 30 X 13.8 with a height of 14 m, while the overall height of the block of the main gates from the base of the chamber of the gates to the apex of the arch is 55 m (Figure 3).

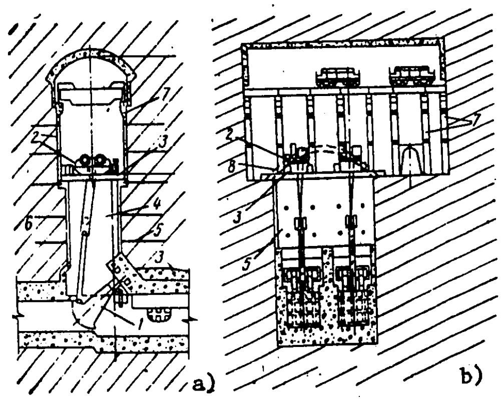

Figure 3. Block of the Main Gates With the Installation of the Mechanisms of Maneuvering According to Temporary Plan. a--longitudinal section; b--cross section; 1--main gate; 2--hoisting mechanism with a lifting capacity of 350 tons; 3--precast reinforced concrete beams; 4--"slot"; 5--wall-strengthening anchors; 6--monolithic reinforced concrete beams; 7--columns; 8--reinforced concrete arch according to the initial version

The rock, which houses the block of the main gates, is represented by strong, but cracked strata of sandstones 1-3 m thick, which alternate with a few interstratifications of aleurolites.

The main operations on erecting the blocks of the main gates of the construction tunnels of tiers II and III consisted in the following:

the driving of the tunnel section of the gates;

the cutting of the compartment of the hoisting mechanisms of the gates with the erection of the concrete supporting arch;

the crosscutting of the "slot" between the compartments of the hoisting mechanisms of the gates and the chamber of the gates;

the construction over the "slot" of two reinforced concrete arches, on which the columns for the placement of the supporting beams for the overhead cranes should rest;

the installation of the gates with the fixed pieces and their concreting in the chamber of the gates by means of the overhead cranes;

construction and installation work by means of the overhead cranes on the development of the "slot" and the completion of the installation of the equipment /4/.

The need to build reinforced concrete arches over the "slot" is dictated by the fact that after driving the 21-m "slot" the installation overhead cranes, which are located in the compartments of the hoisting mechanisms, should operate in order to perform the subsequent construction and installation operations. The arches serve as a supporting structure of the columns of the crane-supporting beams over the shaft of the "slot" /5/.

In connection with the considerable lag of the construction and installation operations on the construction of the block of the main gates of the spillway in early 1978 a difficult situation arose with the assurance of the safe passage of flood waters through the spillway and on the subsequent filling of the reservoir /6/.

The state of the construction and installation work being done on the block of the operating gates was as follows: in the compartment of the hoisting mechanisms of the gates the cutting of the lower bench was completed under the protection of the completed reinforced concrete arch; only the tunneling had been completed over the tunnel section of the chamber of the gates; in the area of the construction of the "slot" a still untouched block of rock remained. In a short interval of time it was necessary to carry out the cutting of 14,650 m^3, to pour 5,000 m^3 of underground reinforced concrete and to install 1,550 tons of the most complex metal components and equipment, and all this was under the cramped conditions of the underground structures with only the slightest opportunity for the simultaneous performance of operations.

Of course, in the arisen situation it was necessary before the operation of the spillway to perform on the block of operating gates at least the minimum amount of construction and installation work, which ensures the necessary operation of the gates. Here it was necessary to take into account the special work of the block during the forthcoming high water period: the reduced heads and discharges, as compared with the rated ones, as well as the brief (for 1-1.5 months) operation of the spillway. It was proposed to install the block of the main gates according to a temporary plan: to carry out the maneuvering of the segmented gates not by permanent hydraulic hoists, for the installation of which it would have been necessary to perform nearly all the work on this block, but by a different hoisting mechanism according to a simplified kinematic diagram.

For this purpose as one of the versions it was proposed to use temporarily cable mechanisms with a lifting capacity of 350 tons, which were intended for the next section of the water intake of the GES, but had already arrived at the construction site. To mount the cable mechanisms it was proposed to throw supporting beams over the "slot" (Figure 3). Such a proposal made it possible to postpone the performance before the next high water of the development of the compartments of the hydraulic hoist of the seal and the crank mechanisms and the installation of the equipment, the amount of which was 4,200 m^3 of reinforced concrete and 650 tons of metal components.

At the same time proposals were adopted on the carryover of a portion of the work of the compartment of the hoisting mechanisms of the main gates to the period after the high water and on the making of the columns in the precast monolithic version. However, for the purpose of expediting the work it was necessary to reject the traditional method of building such blocks by means of arches (the columns rest on specially left rock pillars) and to begin the work with installation cranes. Having reviewed the means of installing the blocks of the gates, an opportunity was found to reduce the width of the "slot" from 13.8 to 10.8 m, while it was proposed to rest the base of the columns on the rock pillars, which were obtained by means of this.

However, taking into account the degree of disturbance of the rock of the pillars and the possible spalls, on the pillars for the bases of the columns it was tentatively decided to make monolithic reinforced concrete beams, the strains of which would be transferred to the subsurface strata of rock by means of reinforced concrete anchors. For the purpose of shortening the construction period the design of the columns was elaborated in a precast monolithic version (Figure 4). The reinforced concrete elements of the columns with a length of 5 m each and a weight of 4 tons were manufactured at a plant, and the reinforcement projecting into the monolithic part of the column and the extensions for joining with the reinforcement of the walls were also incorporated in them. These elements were delivered to the compartment, were installed in the planned position by a truck crane, were joined with each other and with the completed part of the columns, as well as with the anchors, were covered with a mesh concrete form and made monolithic with concrete. The equipment of the "slot" was carried out at the same time as the installation of the columns and their making monolithic: the line of the smooth break from the bore holes 80 cm apart and the loosening bore holes were made using four NKR machine tools. Thus, by the time of the blasting of the "slot" the columns and beams under the crane were ready, and the overhead cranes had been installed on them. By the same time in the flow-through section of the chamber of the gates the metal facing of the race, the walls and the pier had been installed and made monolithic with concrete. During the blasting the completed components were protected by logs from the effect of the shockwave and pieces of rock.

Immediately after the blasting of the "slot" by means of the installed cranes they carried out the trimming of the rock and the strengthening of the walls of the "slot" with reinforced concrete anchors, which in combination with sprayed concrete were the temporary support of the walls of the "slot" for the period of temporary operation.

The blasted rock was loaded by the PNB-3K rock loader into MAZ-503 dump trucks and carried to the surface, while some of the rock, in order to free more quickly the space under the "slot" for installation, was temporarily moved by bulldozer to the space between the gates.

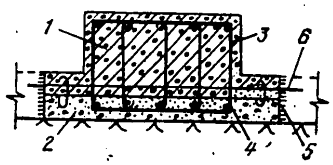

Figure 4. Cross Section of the Reinforced Concrete Column. 1--precast part of the column; 2--monolithic part; 3--reinforcement in the precast part; 4--extensions of the reinforcement into the monolithic part; 5--end mesh concrete form; 6--extensions of the reinforcement into the walls abutting on the column

The installation of the elements of the segmented gates with a total weight of 250 tons and of their fixed parts along with the eccentric supports with a total weight of 385 tons was carried out using the overhead cranes.

Thus, in a short period of time, in three months, there were carried out in the underground block of structures of the main gates of the subsurface spillway: 12,100 m^3 of tunneling, 800 m^3 of reinforced concrete, 500 reinforced concrete anchors, 850 tons of metal components and equipment were installed. Then they began the installation of the temporary circuit of the maneuvering of the operating gates of the spillway. According to the temporary plan of the maneuvering of the gates it was envisaged to place both of the hoisting mechanisms on beams thrown across the slot: two beams for each mechanism. The precast reinforced concrete beams measuring 1.0 X 1.2 X 12.8 m and weighing 40 tons were delivered to the compartment and were installed by the overhead cranes in the planned position.

For the purpose of the uniform transfer of the stresses from the beams to the pillar of rock at the place of their resting in much the same way as the block of the resting of the columns they made a monolithic reinforced concrete beam with reinforced concrete anchors. The mechanisms installed on the beams by means of cables with pulleys were connected with the gates, while the eccentric support was checked by means of levers with anchors in a preset position. In this form the block of operating gates was ready for the regulated passage of discharges through the spillway /6/.

By August 1978 the spillway with the temporary circuit of the maneuvering of the main gates was ready for the discharge of excess water during the filling of the reservoir. The spillway operated for 1.5 months with a discharge of 300-1,000 m^3/sec at heads of 50 to 75 m. The operation of the temporary circuit of maneuvering proceeded successfully without any snags.

After the spillway was shut, the beams and mechanisms were removed, and the builders began the completion of the construction of the block of the main gates according to a permanent plan.

Conclusions. 1. The consideration of the special conditions of the passage of discharges through the spillway this year made it possible to adopt a temporary circuit of the maneuvering of the main gates and to complete the construction of the spillway by high water by means of the reduction of the amounts of construction and installation work and the shortening of the construction period.

2. The making of supporting components of the underground block of the operating gates out of precast reinforced concrete made it possible to shorten the construction period of the block by means of the simultaneous performance of construction and installation work.

3. The adoption of supporting components made from reinforced concrete in combination with anchors made it possible to reject the traditional means of building similar structures using reinforced concrete arches.

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ELECTRIC POWER

CONSTRUCTION, OPERATING ACHIEVEMENTS DETAILED

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 6, Jun 80 p 49

/Article: "Chronicle of Construction and Operation"/

/Text/ During the first days of April 1980 the Chirkeyskaya GES on the Sulak River in the mountains of Dagestan generated the 9 billionth kWh of electric power since the beginning of operation and the start-up of the first unit in 1976. It is the most powerful electric power station (1 million kW) of the Sulak Cascade. Let us recall that this GES has a unique concrete arch dam nearly 240 m high. About 3 billion m^3 of water have been accumulated in the reservoir which was created by this dam.

The construction of the largest pumped-storage electric power station (GAES) in Europe, the Kayshyadorskaya GAES, which is being built on the right bank of the Kaunas Reservois, has begun in the Lithuanian SSR.

The eight turbines of this GAES with a capacity of 200,000 kW each, receiving the excess of electricity at night and operating during that time in the pumping mode, will pump water from the Kaunas Reservoir into a pond, which is located at a height of 100 m with respect to the water level in the Kaunas Reservoir. During the day (the peak hours) the water is released from the high pond and all eight turbines, operating in the turbine mode, will generate electric power.

The Kayshyadorskaya GAES will be able to generate 2.4 billion kWh of electric power annually. This is approximately 25 percent of the electricity consumed in the republic. The current from the new station will pass through six high-voltage electric power transmission lines to a number of industrial centers.

The construction of the high storage pond will make it possible to irrigate more than 7,000 hectares of pasture, meadows and plowland. For the growing industrial city of Kayshyadoris this pond will completely solve the problem of water supply. Nature conservation interests were taken into account when drawing up and appraising the plan of the GAES on the Kaunas Sea.

The electric power stations of the cascade of the Vygskaya GES's generate almost half of the electric power consumed by the enterprises of the Karel'skaya ASSR. In March 1980 a new 330-kV electric power transmission line 300 km long was put into operation. The power workers have successfully assimilated the equipment of the new substation, the latest means of protective relaying and automatic equipment. Work is being performed on the renovation of the hydraulic generators of the hydroelectric power stations of the cascade. During the renovation of these GES's new technical solutions were checked for the first time in practice. During the renovation of the hydraulic turbogenerator unit at the Matkozhnenskaya GES it was necessary to replace the winding of the stator. Modern insulating materials, which lengthen the life not only of the stator, but also of the hydraulic generator as a whole, were used here. The experience of repairing the stator of the Matkozhnenskaya GES yielded positive results. Since being repaired the generators of this GES have operated very reliably.

A hydroelectric power station is being built on the Kureyka River in Krasnoyarskiy Kray. The preparation for the construction of the dam is being completed at the construction site of the GES. The Ust'-Khantayskaya GES is providing power to the construction project; a permanent electric power transmission line has been laid from it. In a few years the current will pass through this electric power transmission line in the opposite direction. The Kureyskaya GES will be hooked up to the power circuit of Taymyr.

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ELECTRIC POWER

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ELECTRIC STRENGTH OF INSULATOR CHAINS, AIR CLEARANCES

Moscow ELEKTRICHESTVO in Russian No 5, May 79 pp 1-5

/Article by Candidate of Technical Sciences Yu. M. Gutman, Corresponding Member of the USSR Academy of Sciences N. N. Tikhodeyev of the Scientific Research Institute of Direct Current (USSR), P. Young of the Electric Power Research Institute (United States) and Doctor H. Schneider of General Electric (United States): "The Electric Strength of Insulator Chains and Air Clearances on a 1,150-kV Pole"*/

/Text/ In the past decade extensive studies of air and line insulation with pulses, which imitate the switching surges in EHV and UHV electrical systems, have been made at a number of major high-voltage laboratories of the world. The studies on outdoor sites with the greatest test voltages in the United States were made using pulse voltage generators with an edge of pulses of 1.5 to 1,000 microseconds /1/, and in the USSR on cascades of test transformers with an edge of pulses of 3,000-5,000 microseconds /2/. However, in these works there were practically no tests on full-scale models of 1,150-kV poles. Moreover, only some tests were conducted with predischarge times of more than 500 microseconds and voltages of more than 2 MV. Finally, the differences in the results of the published studies under comparable conditions turned out to be quite significant /3/.

When preparing for the construction in the USSR and the United States of AC overhead UHV lines a very wide range of switching surges in the lines, which are possible in the process of operation, was taken into account. To coordinate the insulating it was necessary to obtain anew the volt-second characteristics of the air and line insulation on the pole of the 1,150-kV line over the entire possible range of predischarge times. By the start of the work on the joint program neither of the two interested countries had been able to make a study over the entire range of predischarge times due to the lack of a complete set of test equipment. The program of the joint

*The article is being published in accordance with the recommendations of the Soviet-American Coordinating Committee for Cooperation in the field of research, design and operation of extremely high and ultrahigh voltage electric power transmission.

Soviet-American studies afforded a unique opportunity to obtain these data. In the United States the work on this program was financed by the EPRI (Electric Power Research Institute) and was performed by General Electric in Pittsfield (Massachusetts). The American part of the program covered the range of predischarge times of 100 to 1,200 microseconds and was performed using outdoor pulse voltage generators. The Soviet part of the program was performed at the High-Voltage Current Laboratory of the Scientific Research Institute of Direct Current using an outdoor cascade of test transformers. Here the objects of the tests at both high-voltage laboratories were the same.

Objects of the Tests and Methods of the Experiments. The objects for the joint tests were chosen with allowance made for the possible technical solutions for first lines of 1,150 kV in the USSR [2] and 1,200 kV in the United States [4]. When drafting the program of the joint studies much attention was devoted to the assurance of the identity of the conditions of the tests. For this purpose the height of the pole and the wire, the configuration and linear dimensions of the pole and its components and the configuration of the model of the multiple wire were regulated. The joint tests were conducted on models of the intermediate pole, which are similar to the real poles intended for use on 1,150-kV overhead electric power transmission lines (Figure 1). A special experimental pole was developed and produced at the Scientific Research Institute of Direct Current for conducting the experiments. A model of the opening of the pole for suspension between the stanchions of the existing experimental portal pole was developed for the American experiments [1]. The vertical chains of the terminal phase were suspended on the exterior of the crosspiece of the same pole and on the model of the pole of the same dimensions, which was formed by the beams of a self-propelled hoisting crane.

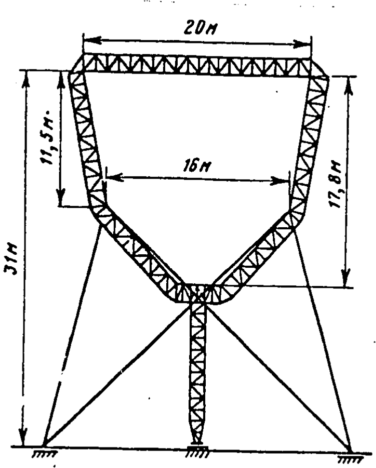

Figure 1. Model of 1,150-kV Pole

The height of the pole to the crosspiece at the first stage of the studies was taken to be equal to 30.4 m in conformity with the height of the existing American experimental pole. The models of the multiple wire reproduced the configuration of the wire of a 1,150-kV line (the eight components and the radius of splitting of 0.75 m). The fittings for attaching the wire to the chains did not have screen rings. The lower insulators of the chain were on approximately the same level as the two closest components of the wire. The insulator chains on the pole were tested at several identical distances from the wire to the crosspiece: from 6 to 8 m for vertical chains and from 5 to 8 m for V-shaped chains. The vertical chain, which supports the terminal phase, was suspended at a distance of 8 and 10 m from the stanchion of the pole. Soviet and American insulators, which have a close value of $H/D \approx 0.55$, which should have ensured identical conditions not only for dry discharge, but also for wet discharge tests, were selected for ensuring the identity of the tests in the two laboratories. The small differences in the test objects, which are evident from Table 1, in the opinion of the authors, could not have influenced the results of the experiments.

Table 1

Component of tested object	Characteristics of tested objects	
	USSR	United States
Volumetric lattice girders of pole	1.4 X 1.4 m	1.2 X 1.2 m
Diameter of components of wire	2.4 cm	3.1 cm
Length of model of wire	60 m	30 m
Type of insulators	Glass PS-12A H = 138 mm D = 260 mm L = 325 mm	Porcelain H = 146 mm D = 254 mm L = 280 mm
Type of chains	Single	Paired, 45 cm between parallel arms

The oscillatory (cosine) pulses of positive polarity with a time of the rise of the voltage of 2,000 to 6,000 microseconds, which were used in the Soviet experiments, were generated by the discharge of capacitor batteries on the low-voltage windings of a cascade of transformers of $3 \times 600\sqrt{2}$ kV /5/. The tests of the chains in the United States were conducted with aperiodic (exponential) pulses of 100 X 3,500, 225 X 4,000, 500 X 3,800 and 1,200 X 4,800 microseconds from pulse voltage generators of 6,000 kV, 300 kJ /1/. The methods of conducting the experiment and measuring the high voltage in both laboratories were similar. The discharge characteristics were obtained in the form of the dependence of the probability of discharge on the amplitude of the pulse by applying to the object 20 pulses each of a voltage with an equal amplitude at each of the 4-8 stages of voltage, which follow after equal intervals. In accordance with the experimental values of the relative frequencies of the discharge the parameters of the Gaussian law of distribution were calculated: $\bar{U}$ is the amplitude of the pulse, which corresponds to a probability of discharge of 50 percent, and σ is the standard deviation.

Control Experiments for the "Core-Plane" Air Clearance. The goal of the control experiments was the achievement of uniformity in the methods of the experiment and the measurements of the discharge voltages at both laboratories on the simplest "core-plane" air clearance with a length of 6 and 10 m. The experiments were conducted at outdoor test sites under adequately similar conditions.

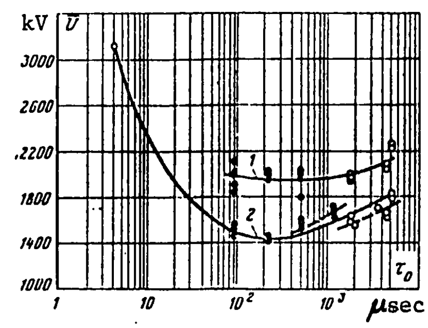

Figure 2. Volt-Second Curve of $\bar{U}$ (τ_0) of the "Core-Plane" Air Clearance. 1--10 m; 2--6 m; the dark points are the U.S. data, the light points are the USSR data.

The volt-second curves of the "core-plane" air clearances with a length of 6 and 10 m depending on the total time of the rise of the voltage from zero to the amplitude of the switching pulse τ_0 are cited in Figure 2. For the "core-plane" clearance with a length of 6 m there is a pronounced minimum of the volt-second curve in the case of a switching pulse with a time of rise of about 200 microseconds. For the clearance with a length of 10 m the minimum of the volt-second curve is less distinct. The weak dependence of the volt-second curve on the slope of the edge for the clearance with a length of 10 m has the result that the difference in the form of the aperiodic and oscillatory (cosine) pulses does not influence the value of the discharge voltages, which join each other well, forming a smooth characteristic curve. The difference in the results of the two series of American tests of the clearance of 10 m with the same form of pulse apparently results from the influence of the absolute humidity of the air in much the same way as the influence noted in /6/.

The slight difference of the discharge voltages of the clearance of 6 m, which were obtained at the two laboratories given pulses with τ_0 = 1,200-2,000 microseconds, can be explained by the greater slope of the edge of the oscillatory pulses as compared with the exponential pulses with the same total time of the rise of the voltage. A similar difference of the discharge voltage of the "core-plane" clearance with a length of 2 m in the case of oscillatory and exponential pulses with $\tau_0 = 1{,}000$ microseconds, which reaches 20 percent, was noted earlier in /7/. The best convergence of the data of both laboratories with different forms of the pulse is obtained with the use of a criterion which takes into account the specific nature of the form of the pulse. This criterion is based on the analysis of the interval of time, which is defined as the "active part" of the edge of the pulse, that is, that interval of time, within which the occurrence of a discharge is possible. Such an approach is acceptable when the discharge occurs up to the amplitude of the switching pulse, which for the "core-plane" clearances with a length of 6-10 m occurs in the case of a positive polarity of the pulses with edges of more than 250 microseconds.

From the experiments of many laboratories it is known that the minimum voltage, at which the occurrence of a discharge is possible, will be approximately 3σ less than $\overline{U}$. As an example let us indicate that in the Soviet experiments for pulses with a time of rise to the amplitude of 2,000 microseconds and 5,000 microseconds the smallest actual discharge voltage was respectively $0.83\ \overline{U}$ and $0.78\ \overline{U}$. For the majority of forms of the pulse, which are of practical significance, all the possible values of σ fall within the range of 5 to 10 percent. Thus, the "active part" of the edge of the pulse cannot be lower than the point which pertains to 70 percent of the amplitude of the pulse which corresponds to a 50-percent probability of a discharge. This makes it possible to define the active part of the pulse as the section of the edge of the pulse between $0.7\ \overline{U}$ and $\overline{U}$, to which the interval of predischarge times $\tau_{0.7}$ corresponds.

Such an approach to the evaluation of the form of the surges in electrical systems and of the test pulses in laboratory experiments had already been suggested earlier /1 and 2/. Its merit consists in the convenience of the approximate equalization of the pulses, which differ in form, in the great conformity to the notions about the mechanism of discharging and in the valid ignoring of that area of the edge of the pulse (less than $0.7\ \overline{U}$), which does not play a decisive role in the development of the discharge. As is evident from the oscillograms of Figure 3, in spite of the appreciable difference of the form of the oscillatory ($\tau_0 = 1{,}800$ microseconds) and exponential ($\tau_0 = 1{,}000$ microseconds) pulses with small values of the voltage, their "active parts" of the edge $\tau_{0.7}$ are close enough to each other, which is also responsible for the small differences in the discharge voltages. The evaluation of the form of the pulse for the time $\tau_{0.7}$ considerably improved the convergence of the volt-second curves of the clearance with a length of 6 m (Figure 4): the maximum difference of the data for close forms of the pulse at both laboratories does not exceed 5 percent.

Volt-Second Curves of Dry Vertical and V-Shaped Chains. The obtained dependences of the discharge voltages on the total time τ_0 and the "active" time $\tau_{0.7}$ of the rise of the voltage of the switching pulse for different air clearances from the wire to the crosspiece of the pole in the case of a V-shaped chain in the opening of the pole are presented in Figures 5 and 6. The minimum of the volt-second curve is distinguished with a total predischarge time of about 200 microseconds or less, and this time decreases with a decrease of the length of clearance. With a lengthening of the time of the rise of the voltage of the pulse from 200 microseconds in the case of the minimum of the volt-second curve to 6,000 microseconds the increase of the electric strength of the air clearance was about 20 percent.

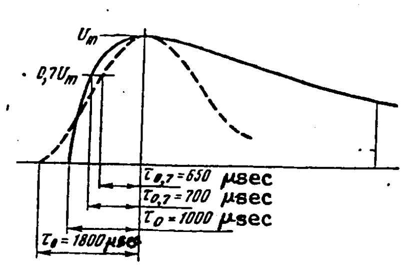

Figure 3. Aperiodic (τ_0 = 1,000 microseconds) and Oscillatory (τ_0 = 1,800 microseconds) Pulses With Practically the Same "Active Part" of the Edge

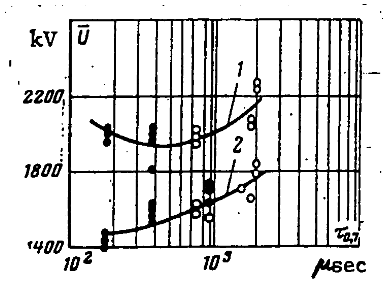

Figure 4. Volt-Second Curve of $\overline{U}$ ($\tau_{0.7}$) of the "Core-Plane" Air Clearance Depending on the "Active Part" of the Edge of the Pulse. The symbols are the same as in Figure 2.

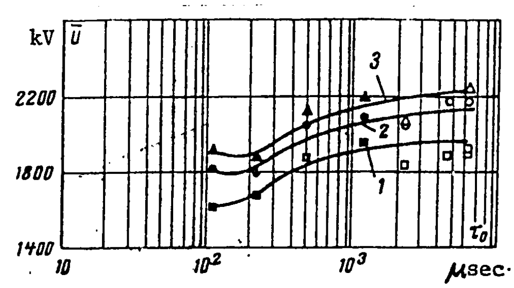

Figure 5. Volt-Second Curve of $\overline{U}$ (τ_0) of the Air Clearance Between the Wire and the Crosspiece of the Pole for a Dry V-Shaped Chain in the Opening of the Pole. 1--the distance from the wire to the crosspiece is 5 m; 2--6 m; 3--7 m; the dark points are the U.S. data, the light points are the USSR data.

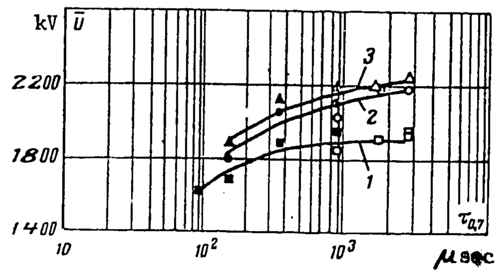

Figure 6. Volt-Second Curve of $\overline{U}$ ($\tau_{0.7}$) Depending on the "Active Part" of the Edge of the Pulse for the Same Conditions as in Figure 5.

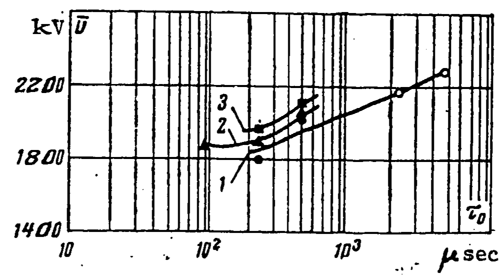

Figure 7. Volt-Second Curve of $\overline{U}$ (τ_0) of a Dry Vertical Chain (Terminal Phase). 1--the distance from the wire to the crosspiece is 6 m; 2--7 m; 3--8 m; the dark points are the U.S. data, the light points are the USSR data.

The corresponding volt-second curves of the vertical chains depending on τ_0 and $\tau_{0.7}$ (Figures 7 and 8) are analogous in their form to the ones cited in Figures 5 and 6. The minimum of the curve can be assigned to the times between 100 and 200 microseconds. The discharge voltage of the vertical chain with a length of 6 m in the case of an increase of the time of the rise of the voltage from 250 to 4,600 microseconds increased approximately 25 percent. The discharge voltages of the vertical chain on the terminal phase were usually slightly higher than for V-shaped chains in the opening of the pole. For pulses with τ_0 = 225-500 microseconds this difference was on the average about 2 percent, while for pulses having τ_0 from 1,200 to 4,600 microseconds it was on the average 6 percent.

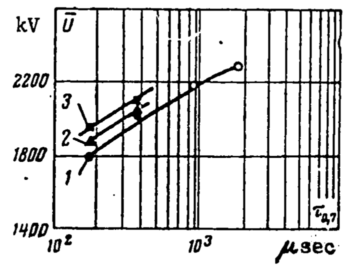

Figure 8. Volt-Second Curve of $\bar{U}$ ($\tau_{0.7}$) Depending on the "Active Part" of the Edge of the Pulse for the Same Conditions as in Figure 7.

Additional Study of the Influence of Precipitation. It is well known that the discharge voltages in the case of pulses of negative polarity for air clearances and chains of insulators in a dry state are higher than the corresponding discharge voltages in the case of positive polarity /1/. However, for the evaluation of the influence of precipitation tests of vertical and V-shaped insulator chains in the United States with the artificial dampening with torrential rain and with natural precipitation--rain and snow--were conducted with the switching pulses of both polarities. The experiments in the presence of precipitation were conducted on the same objects and under the same conditions as in the dry state, with the exception that the "up-down" method was used in the experiments with artificial dampening. A sprinkler for dampening with artificial rain was placed on the crosspiece of the pole. The streams of rain fell down vertically on the clearances being tested. The intensity of the rain from the sprinkler was regulated at approximately 4 mm/min in windless weather. The actual dampening of the clearance being tested in the presence of wind, apparently, was less and not so uniform. Moreover, individual tests were conducted in the presence of natural precipitation. With pulses of positive polarity, which were used in the experiments in the presence of precipitation, the time of the rise of the voltage of the switching pulse to the amplitude influences the electric strength of the air insulation clearance and the insulator chains approximately to the same extent as in their tests in a dry state.

For V-shaped chains the lowest discharge voltages under the conditions of dampening belong to the positive polarity of the pulse; the tests in the presence of a negative polarity of the pulses always resulted in higher discharge voltages than in the case of a positive polarity of the pulses under dry conditions. The decrease of the electric strength of the clearances in the "opening" of the pole in the presence of artificial dampening as compared with the dry discharge was negligible and on the average was about 2 percent. The discharge voltages of the vertical chains in the presence of artificial dampening and a positive polarity of the pulses were always lower than the dry discharge voltages. Under the same conditions with pulses of negative polarity the discharge voltages at times were lower than both the dry discharge and wet discharge voltages in the presence of a positive polarity. The decrease of the wet discharge voltage in the presence of artificial dampening with both polarities as compared with the dry discharge voltage with a positive polarity was on the average 5 percent. In the presence of natural dampening with rain and snow the discharge voltages of vertical and V-shaped chains virtually did not differ from the dry discharge voltages: the decrease of the electric strength did not exceed 2 percent.

Appendix. The Use of the Obtained Results for Coordinating the Insulation of the 1,150-kV Overhead Line.* The data obtained in the current studies can be used for coordinating the insulation of the 1,150-kV line with anticipated switching surges. The statistical method developed for this in [8] takes into account a large number of individual insulating components on the line and the statistical characteristics of both the electric strength of the insulation and the surges affecting it. In the statistical coordination of the levels of insulation with switching surges it is necessary to take into account that a special place among all switches belongs to the automatic recloser. The probability of the sparkover of the insulation of the line in the presence of an automatic recloser after a short circuit, which was casued by a sparkover in the presence of a working voltage of one of the dampened chains, should be determined according to the 50-percent discharge voltage also of a slightly fouled damp chain.

In the presence of an automatic recloser after a short circuit, which has been caused by storm damage of the lines, which usually coincides with torrential rain, the probability of a sparkover of the insulation of the line is determined according to the 50-percent wet discharge voltage of the chain in this state. For 1,150-kV lines the length of the chain is determined first of all according to the working voltage and will be 7-8 m. Due to the inadequate amount of data, which were obtained in the presence of natural rain, let us take for determining the levels of insulation the magnitudes of the discharge voltages, which were obtained in the presence of artificial moistening, $k_{и} = \overline{U}_2/u_{\phi\ max}$, which according to the data of [9] for slightly fouled chains practically coincide.

For V-shaped chains, which have shorter clearances between the wire and the crosspiece of the pole, the coordination of the insulation should be carried out for these air clearances with levels of insulation, which are designated as $k_V = \overline{U}_2/u_{\phi\ max}$. For an overhead line without dischargers the probability of a sharkover of the line insulation in one switch can be estimated by the formula:

$$P_{н} \approx F\left(\frac{\bar{k} - \overline{K}_{н}}{c_{к}\bar{k}}\right) = F(\Delta). \qquad (1)$$

*The work on coordinating the insulation of the 1,150-kV overhead line was performed by Yu. M. Gutman and N. N. Tikhodeyev.

Here it is assumed that the frequencies of switching surges follow the normal law with the parameters $\bar{k}$ and $c_K\bar{k}$, while the level of the insulation of the line as a whole $\bar{K}$ is calculated according to the level of the insulation of one element $\bar{k}_H$ in the following manner: $\bar{K}_H = (1-ac_H)\bar{k}_H$, where the coefficient a depends on the number of insulating elements on the line [9]. For an overhead line, which is protected by dischargers, the probability of a sparkover of if only one element of the insulation in one switch can be estimated by the formula:

$$P'_H \approx F_0 \left[\frac{\bar{k}_0 - \bar{K}_H}{\sqrt{(c_0\bar{k}_0)^2 + (bc_H\bar{k}_H)^2}} \right] F(\Delta) = F_0(\delta)\, F(\Delta), \qquad (2)$$

where the first factor characterizes the effectiveness of the protection of the insulation by the discharger with a level of the breakdown voltage $\bar{k}_0$ and the root-mean-square scattering of the breakdown voltages $c_0\bar{k}_0$, $c_0 = 0.04$, while b reflects the decrease of the scatterings of the discharge voltages for the insulation of the line as a whole as compared with the scattering of the discharge voltages $c_H = \sigma/\bar{U}$ of one component.

For the Itat-Novokuznetsk 1,150-kV pilot industrial electric power transmission line it is planned to use single vertical and V-shaped chains and the protection of the insulation of the line by dischargers with $\bar{k}_0 = 1.7$ [2]. On the line with overhead switches, 100-percent compensation by reactance coils and switching on for the break of the automatic recloser in sequence with each reactance coil of the resistor for the discharge of the strong phases of the line during the break of the automatic recloser the surges in the switching of the automatic recloser can be characterized in the following manner: the parameters of the distribution of the frequencies are the mean impact coefficient $\bar{\chi} = 1.61$, $c_\chi = c_K = 0.11$ [9]; the mean value of the induced component of the surges of industrial frequency in the presence of the automatic recloser of $\bar{v} = 1.15$; $\bar{k} = \bar{\chi}\bar{v} = 1.61 \cdot 1.15 = 1.85$; the lowest frequency of the free oscillations is $\beta_1 = (3-4)\,\omega$.

According to preliminary estimates the anticipated proportion of emergency shutdowns on the 1,150=kV overhead line will be 0.25 (0.15 in storms and 0.1 with an operating voltage). The length of the line is 270 km. Consequently, on this line about one sparkover a year is anticipated, and sufficiently effective automatic reclosing will be ensured even with a probability of a sparkover of the line insulation during the switching of the automatic recloser of $P_H \approx 0.1$. For a line with reactance coils at the ends and with a primary frequency of the free oscillations of $\beta_1 = (3-4)\,\omega$ it is possible to take: $a = 2.7$ and $b = 0.32$ [8]. Taking into account the imposition of these oscillations on the voltage of industrial frequency, $\tau_{0.7}$ will be accordingly 1,000 microseconds (3ω) and 600 microseconds (4ω). For wet discharge voltages of vertical chains in this case $c_H = 8$ percent, for V-shaped chains $c_H = 6$ percent.

The estimates of the probabilities of the sparkover of both types of chains in the switching of the automatic recloser for a 1,150-kV overhead line, which is not protected and is protected ($k_o = 1.7$) by reactance coils, are cited in Table 2 on the basis of the data of Figures 6 and 8, which pertain to $\tau_{0.7} = 600$ microseconds (which corresponds to a lower strength than in the case of $\tau_{0.7} = 1{,}000$ microseconds) with allowance made for the decrease obtained in the experiments of the electric strength of vertical chains $k_{и1}$ and V-shaped chains $k_{и3}$ in the presence of precipitation. A greater efficiency of the automatic recloser is achieved on a 1,150-kV overhead line with vertical chains 8 m long in the case of the use of dischargers. Additional measures on the more complete limitation of surges are necessary for the vertical chain 7 m long and for both versions of the V-shaped chains, since the level of insulation of the vertical chain 7 m long and both V-shaped chains is considerably lower. A similar situation occurs at 1,150-kV substations, where it is necessary to take into account high-frequency switching surges, for which $\tau_{0.7} \geq 50$ microseconds, and the decrease of the electric strength of the chains and air clearances by up to 20 percent in the zone of the minimum of the volt-second curves. In the latter case it is also possible to agree to the lengthening of the chains and the clearances.

Table 2

Chain	Length of chain, m	$\tau_{0.7}$ microseconds	Value of $P_и$ and $P'_и$ for the insulation of a 1,150-kV overhead line								
			$\bar{k}_{и1}$	$\overline{K}_{и1}$	$\bar{k}_{и3}$	$\overline{K}_{и3}$	Δ	$P_и = F(\Delta)$	δ	$F_0(\delta)$	$P'_и = F_0(\delta)F(\Delta)$
Vertical	7	600	2.20	1.73			0.59	0.72	-0.3	0.38	0.20
	8		2.28	1.79			0.29	0.61	-0.85	0.20	0.10
V-shaped	7				1.90	1.59	1.27	0.9	1.1	0.86	0.75
	8				2.02	1.69	0.78	0.78	0.1	0.54	0.40

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FUELS

RESULTS OF GAS EXPLORATION FOR THREE YEARS OF FIVE-YEAR PLAN

Moscow GAZOVAYA PROMYSHLENNOST': SERIYA: GEOLOGIYA, BURENIYE I RAZRABOTKA GAZOVYKH MESTOROZHDENIY. (EKSPRESS-INFORMATSIYA) in Russian No 5, 1980, pp 7-11

[Article by G. P. Volkova, Ye. V. Kudyashov, G. A. Todkina, I. F. Tatik, VNIIEgazprom (All-Union Scientific Research Institute of Economics, Production Organization and Technical-Economic Research in the Gas Industry): Basic Results of Geological Exploration Work in Gas in the USSR for 3 Years of the 10th Five-Year Plan]

[Text] "The principal directions for growth of the national economy of the USSR for 1976-1980" in the 10th Five-Year Plan in conformity with resolutions of the CPSU 25th Congress call for an increase of gas recovery to 435 billion m^3 annually. The accelerated growth of recovery requires a significant increase in efficiency of the searching and prospecting operations, and also an improvement in the quality of preparation of reserves. Thus the State Plan for development of the USSR national economy in 1976-1978 calls for strengthening geological exploration operations for gas in the north Tyumenskaya Oblast', Yakutskaya ASSR, Arkhangel'skaya Oblast', Komi ASSR, Central Asia, Kazakh SSR (border areas of the Caspian depression), in shelf zones, and also in the oil and gas extracting regions: Ukrainian SSR, Northern Caucasus, and Uralo-Povolzh'ye.

As a result of geological exploration operations in the USSR during the period under consideration were planned for increasing reserve stocks of gas was 106.3 percent fulfilled (free and in gas caprocks).

The main increase in gas reserves (75.6 percent) was obtained in the northern regions of Tyumenskaya Oblast', developed as a result of concluded prospecting of earlier opened fields (Urengoy, Kharasaveyskoye, Bovanenkovskoye, Pestsovoye, Yamburgskoye etc.), as well as in newly opened fields of Kruzemshternovskoye, Kharvutinskoye, etc.

The plan for increasing gas reserves in Uzbek SSR was significantly overfulfilled, the plan for Ukrainian, Kazakh, and Azerbaijan SSR was fulfilled. For the remaining gas-bearing regions of the country the planned figures of increase were not achieved, principally because of the limitation of funds for promising structures (Table 1).

During the period under consideration in the territory of the USSR 103 new fields were opened up (Table 2) with a total preliminary estimate of gas reserves of about 3.5 trillion m^3. Fifty-six fields belong to the European territory and 47 to the Asiatic sections of the country. The majority of fields in the European section of the country are small, except for the Astrakhan and Intinskiy, which were opened in the northwest of the USSR.

Table 1

Fulfillment of the plan for increasing gas reserves (free and in gas caprocks) for 1976-1978

Regions	Fulfillment of plan, %
USSR	106.8
European Section	59.7
Asiatic Section	114.9
RSFSR	106.7
including:	
North-West	50.0
Uralo-Povolzh'ye	47.0
Northern Caucasus	27.3
Western Siberia	126.1
Eastern Siberia	29.5
Far East	46.1
Ukrainian SSR	102.2
Azerbaijanskaya SSR	123.2
Kazakhskaya SSR	137.0
Central Asia	98.1
including:	
Uzbekskaya SSR	198.0

Huge fields have been opened up in the Asiatic section of the Soviet Union, especially in Tyumenskaya Oblast': Yen-Yakhinskoye, Yuzhno-Samburgskoye, Eastern-Urengovskoye, Kruzenshternovskoye, Antipayutinskoye, Gydanskoye. The last two are the first discoveries of the new gas-bearing region in the north of Tyumenskaya Oblast'.

Twenty-two fields have been opened in Central Asia, and of them the Alanskoye and Uzbek SSR and Uchadzhinskoye, Sayrabskoye, Gagarinskoye and Donmezskoye in Turkmen SSR are quite promising.

In addition, separate beds of gas have been detected in earlier opened fields, which substantially increases the prospects for their gas content.

Table 2 Gas fields opened in the USSR in 1976-1978

	Amount and nature of field				Estimate of reserves by categories of C_2 billions of m^3
	Total number of fields opened	including			
		gas	gas condensate	petroleum gas	
USSR	103	59	35	9	3385--3555
European Section	56	29	31	6	1055--1095
Asiatic Section	47	30	14	3	2330-2460
RSFSR	47	28	16	3	2816-2855
including:					
North-West	4	1	2	1	100-125
Uralo-Povolzh'ye	15	9	5	1	820
Northern Caucasus	10	5	5	-	20-35
Western Siberia	12	7	4	1	1600
Eastern Siberia	1	-	1	-	50
Far East	5	5	-	-	225
Ukrainian SSR	23	14	7	2	115
Azerbaijanskaya SSR	1	-	-	1	--
Kazakhskaya SSR	7	2	8	2	55-60
Central Asia	22	16	6	-	400-525

All of the explored gas reserves are contained in 823 gas, gas-condensate and gas-petroleum fields, of which 483 (58.7 percent) are concentrated in the European section of the country.

Of the total number of fields 47 percent are being developed; 10.3 percent are awaiting start-up; 27.4 percent are being explored; 15.5 percent are in reserve. With respect to the reserves confined to these fields, it turns out that 36.8 percent of the opened reserves are being exploited. The old gas-extracting regions, especially in the European sections of the country, have high indications for recovery of the gas resources. Thus, in Uralo-Povolzh'ye and in the Northern Caucasus almost 85 percent have been brought into development and in the Ukrainian SSR 74.6 percent of the opened resources are being exploited, which are numbered in the balance of these regions.

In the new gas-extraction regions the overwhelming portion of fields is being explored or being prepared for exploitation. For example, in Western Siberia the portion of such fields is 70 percent, and in Eastern Siberia it is 75 percent. On the other hand, the lack of reserves prepared for development in Uralo-Povolzh'ye, Ukrainian SSR and in the Northern Caucasus is evidence of the extreme situation of gas recovery which can be created in these regions in the near future.

At the same time one should note that the reserve of gas stocks prepared for development, being mainly connected with the large fields in Western Siberia and Central Asia, is evidence of the large potential possibilities for their utilization in industry.

In the 3 years of the 10th Five-Year Plan which have gone by the conversion ratio for reserves, which is calculated as the ratio of the exhausted gas reserves to extraction, was 6.4 for the country as a whole. In the European regions it was 1.6, and in the Asiatic regions it was 10.6.

The greatest conversion factor (replenishment) for reserves was found in the Far East--45.1 and in Western Siberia--23.8.

In the Far East the high factor for replenishing of reserves is caused by a low level of gas recovery, and in Western Siberia there is significant overfulfillment of the plan for increasing gas reserves, which are considerably ahead of the constantly increasing gas recovery. In the remaining regions of the USSR the replenishment factor varies in the range 1.8-2.9, with the exception of Ukrainian SSR where replenishment of gas reserves is at a level of 0.97; i.e., gas extraction is almost covered by existing increases in gas reserves. In Komi ASSR the factor is 0.2 and in the Northern Caucasus it is 0.06; i.e., in these regions gas production is achieved exclusively by existing reserves.

The existence of a stock of promising structures, new dimensions, and the estimate of reserves are the basis in planning searching and exploratory operations for the future. The total stock of structures in the USSR as of January 1, 1979 was 1259, of which only 389 structures were considered in the distribution of gas.

In 1978, as a result of an examination of the geological materials by regions, a large number of the prepared structures were written off from the balance because of their poor prospects, which included 223 for Uralo-Povolzh'ye, 136 for Central Asia, and 60 for the Northern Caucasus. Of the total number of structures (the balance for January 1, 1979) 347 are in Uralo-Povolzh'ye, 159 are in Western Siberia, 113 are in Kazakh SSR, 111 are in Central Asia, etc.

The largest structures are in the territory of Tyumenskaya Oblast', where the average reserves for a single structure are 78.5 billion m^3, in Eastern Siberia they reach 27.3 billion m^3, in the North-West they reach 25.8

billion m^3, 21.9 billion m^3 in Eastern Turkmeniya, 4.1 billion m^3 in Ural-Povolzh'ye, and 4.3 billion m^3 in the Northern Caucasus.

The very high estimate of gas reserves for the structures of Western and Eastern Siberia, the Northwest and Turkmen SSR, in comparison with the other regions, indicates the increased effectiveness of carrying out geological exploration operations for gas in this area. The searches and prospecting for new deposits must be carried out in the future in both the old regions in order to maintain the reserves of the falling levels of recovery, as well as in the promising but poorly studied regions. In the gas-bearing provinces being exploited there must be a redistribution of the amount of drilling to the more promising regions. In the insufficiently studied regions, such as Eastern Siberia, Yakut ASSR, Northern Kazakhstan, and the shelf zones there must be a substantial increase in the geophysical operations in order to precisely define the geological structure of these territories, and to detect and prepare structures in them for searches of petroleum and gas beds.

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FUELS

CURRENT STAGE OF DEVELOPMENT OF GAS-EXTRACTION INDUSTRY

Moscow GAZOVAYA PROMYSHLENNOST'. SERIYA: EKONOMIKA GAZOVOY PROMYSHLENNOSTI. (REFERATIVNAYA INFORMATSIYA) in Russian No 11, 1979 pp 7-11

[Article by R. B. Dadashev and S. G. Gayevaya, PO Nadymgazprom]

[Text] At the current stage of development of gas-extraction industry the problem of improving planning is becoming one of the most urgent ones.

In 1977 a collective of Nadymgazprom association started up the gas field Medvezh'ye with a planned output of gas of 65 billiom m^3. In 1978 it began its period of constant production (65-70 billion m^3).

In order to fulfill this very important national economic task of assuring the growth of gas extraction management of the field was entrusted to the so-called "start-up complex." Construction of facilities by the "start-up complex" meant bringing on board the optimum number of boreholes, the construction of floats, securing boreholes, and assembly of equipment, which are necessary above all for supplying the necessary amount of gas to the main gas pipeline. The remaining boreholes, floats, equipment for boreholes, auxiliary facilities, intra-field and inter-field roads were constructed, erected and put into operation in subsequent periods, sometimes after several years (see table).

In the overall management by "start-up complex" the rates of construction and introduction or residences, facilities for engineering support, municipal and everyday use, commerce and education were significantly slower than the rates of construction of the main technological facilities directly related to gas extraction. As a result by the time Medvezh'ye field was opened the amount of basic capital outlays was 1.0 billion rubles, or 50 percent of the amount envisaged by the plan, including 800 million rubles for commercial construction, or 53 percent, 200 million rubles, or 40 percent, for non-commercial construction. This led to a reduction in cost of 34 percent, a reduction in personnel of 48.7 percent and an increase in the level of capital effectiveness, profitability, labor productivity and return on investment in comparison with the planned amounts. It is evident that in the future the introduction of facilities called for by the plan and in the use of capital outlays will lead to an increase in the number of personnel, to an increase in costs, to a reduction in the effectiveness of funds and labor productivity, and to a decrease in return on investment, i.e., to a worsening of the basic technical-economic indicators of the association.

Dynamics of the cost of UKPG at the Medvezh'ye field

Name of Facility	Operational Start-up date (mo-yr)	Balanced cost for January 1 of each year, millions of rubles 1973	1974	1975	1976	1977	1978	1979
UKPG-1	III-1974	0.4	0.4	58.0	64.0	75.0	67.0	70.9
UKPG-2	IV-1972	43.0	57.0	69.0	71.0	72.0	78.0	87.5
UKPG-3	IV-1973	---	43.0	56.0	73.0	74.0	75.0	86.8
UKPG-4	XII-1974	---	---	41.0	53.0	57.0	61.0	61.0
UKPG-5	IX-1975	---	---	---	76.0	93.0	99.0	99.8
UKPG-6	VI-1976	---	---	---	1.0	74.0	80.0	91.7
UKPG-7	XII-1976	---	---	---	---	50.0	67.0	85.4
UKPG-8	XII-1977	---	---	---	---	---	77.0	83.7
UKPG-9	---	---	---	---	---	---	---	53.6

Worsening of the technical-economic indicators will occur in all subsequent years with respect to the preceding ones until the field is completely used up, but not with respect to the planned indicators.

Upon starting up the Medvezh'ye field to its planned output all of the actual technical-economic indicators of the association Nadymgazprom were better than the planned ones and reached their optimal values. From the very beginning of the period of constant extraction of gas all of the basic technical-economic indicators of the association worsened significantly, while simultaneously approaching the planned figures.

In this manner, a gas-extracting enterprise, while intensively developing and opening up a field to its planned output on schedule, subsequently experiences extremely unfavorable conditions with regard to its technical-economic indicators. This is explained by the fact that planning of all indicators, and of all assignments both for the 5-year plan as well as for each successive year, which is accomplished in conformity with current methods and instructions, i.e., on what was achieved during the preceding (base) period, does not take into account the actual situation with development of the field and does not assure conformity of the achieved indicators to the indicators envisaged by the scheduled assignment.

This method of planning, which is suitable for manufacturing and processing sub-branches, under conditions existing in the extraction sub-industries, may be applicable only with respect to the industry as a whole. Insofar as at the present time the technical-economic indicators are planned on the basis of actual data for the accounting period or in rare cases for a number of years, which precede the planning year, then, as a rule factors are not taken into account which promote or impair the individual indicators according to the convergence of circumstances, which have come about randomly, or by virtue of particular reasons, which do not depend on results of the activity of the enterprise itself.

Of course, the use of statistical data on operation of the industrial association of Nadymgazprom as base data in analysing and planning the basic technical-economic indicators for the future can lead to serious errors, whose elimination will entail great difficulty. Consequently, planning or forecasting improvement of technical-economic indicators of a gas-extraction enterprise(GDP) for the entire period of a field's development, will be completely unrealistic and unsound if normal methods are used.

The experience of intensive construction management of the Medvezh'ye field by the "start-up complex" has shown that the above mentioned factors can manifest during management of other fields north of Tyumen' Oblast' (Urengoyskoye, Vyngapurskoye, Yamburgskoye, and Yubileynoye, etc). If the planning and forecasting of technical-economic indicators of GDP, which include management and operation of Northern Siberian fields are based on the indicators achieved in the preceding periods, then this will lead to large disproportions in the economics of these enterprises and may be revealed in the economics of the industry as a whole.

Operating experience at PO Nadymgazprom has also shown that the planning of 5-year and annual indicators on the basis of current methods and instructions which are common to the industry is inappropriate. There has been a large discrepancy between the projected and confirmed annual planning indicators for the years of the 10th Five-Year Plan which have gone by (1976-1978), and the annual plans were systematically regulated throughout the entire year. Thus, in 1978, the plan for gas extraction was changed several times, which entailed a corresponding correction of the plans for labor and costs. In addition, the plan for personnel was changed three times independently of the production volumes and the plan for wages was changed four times. The reason for these adjustments was the impossibility of foreseeing a number of factors during the average-period planning (a five-year plan), which were related to the degree of capital outlay use.

The degree of capital outlay assimilation directly affects the technical-economic indicators, whereby the more intensively developed the field is the greater the proportion of start-up complex facilities, the greater the lag in facilities of subsidiary and auxiliary enterprises, the more significant this influence and the more necessary it is to consider these factors when planning the basic technical-economic indicators. However, the planning agencies of the higher organizations are not in a position to consider a number of factors for specific circumstances (the error rate of the initial plan in comparison with the actual reaches 6-18 percent). It is normal to assume that if an association reaches the planned output then subsequently there do not have to be additional expenditures. As a result of such an approach to planning, beginning in 1978 the association has experienced a consistent shortage of limits.

From what has been set forth we can conclude that during planning and forecasting of the technical-economic indicators of GDP one must plan these indicators not on the basis of the indicators achieved but rather with consideration of the factors which determine the technical-economic indicators of the enterprise for the future. Naturally, to realize such an approach one must determine one or several principal factors, on which basis one can then calculate the remaining technical-economic indicators.

It has been established by the laboratory of economic investigations of PO Nadymgazprom as a result of the investigations carried out (on the base of actual data for 1972-1978), that the indicator of the introduction of basic funds is such a factor under the specific conditions of management and operation of the northern fields.

The connection of the basic technical-economic indicators being studied to the volume of basic funds injected (average annual cost of commercial-industrial basic funds) is revealed by the aid of a method of mathematical statistics. Empirical formulae of the relation of the average annual cost of industrial funds to the number of commercial-industrial personnel have been found:

$$Ч = 25{,}63 \times \varphi_0^{0{,}608} \times e^{13\cdot 10^{-6}\varphi_0} \qquad (1)$$

and to the wages for the commercial-industrial personnel (thousands of rubles):

$$З = 34{,}46\ \varphi_0^{0{,}8706}\, e^{-1{,}73\cdot 10^{-6}\varphi_0}, \qquad (2)$$

where φ_0 is the average annual cost of the commercial-industrial basic funds, millions of rubles.

The trustworthiness of the derived formulae has been checked by comparing the actual and calculated values of the number of PPP [expansion unknown] and the wage fund for Nadymgazprom association. The mean deviation was 0.1-1.08 percent with a 10 percent allowance for construction. The derived calculated values reflect the actual technical-economic indicators for the period up to planned output and served as a real base for planning of subsequent periods.

Because determination of the principal factor affecting the formation of technical-economic indicators of an enterprise requires a large number of statistical data, prolonged and complex calculations, use of a number of digital indicators, processing a large number of actual and planning material, refinements and introduction of numerous corrections and adjustments, the most effective planning method may turn out to be the method of economic-mathematical modeling.

Insofar as automated systems of control are used at all large GDP, the next stage of operation should be development and introduction of a method for investigating and forecasting the technical-economic indicators of GDP using an economic-mathematical model, programmed for ASU [automatic control system] or an enterprise and OASU [branch automative control system].

The problem experienced by PO Nadymgazprom will be inherent in other gas-extracting enterprises of the industry, which develop large gas fields under similar conditions. Therefore, their positive solution is an urgent task not only of the economic and industrial services of Nadymgazprom association, but also of the economic science of the industry as a whole.

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FUELS

URENGOY FIELD INCREASES PRODUCTION OUTPUT

Moscow GAZOVAYA PROMYSHLENNOST': SERIYA: EKONOMIKA, ORGANIZATSIYA TRUDA I UPRAVLENIYE PROIZVODSTVOM V GAZOVOY PROMYSHLENNOSTI (EKSPRESS-INFORMATSIYA) in Russian No 5, 1980 pp 5-7

[Article by R. A. Sayfulin, V. A. Smirnova of NISTyumengazprom and TSNIS-gazprom]

[Text] Urengoy field occupies an important position in a network of Siberian gas fields, extending for tens of kilometers over the territory of Yamalo-Nemetskiy autonomous district. The presence here of large gas reserves has made Siberia the center of natural gas extraction in place of western regions of the country. Located quite far north of inhabited localities, Urengoy has required a radically new approach to the development of the gas fields.

In 1978, by the anniversary of V. I. Lenin's birth, Urengoy gas was fed into the system of main pipelines going beyond the Ural range. Initial exploitation of the largest field became possible by virtue of the timely introduction of the first complex gas preparation unit, which was constructed in 15 months instead of the planned 28 months. The producers needed only one and a half months in all to reach the planned output of the unit, while equipment changeover went on at the same time as the assembly.

During construction of the field, advanced technological solutions were used, in particular a more rational scheme for distribution of equipment was adopted, intermediate flow access points were eliminated, and gas metering connections in the technological unit were simplified. All of these measures permitted us to reach the projected output of the field.

In 1978, on the day of the 60th anniversary of the Lenin Komsomol, a second unit for complex preparation of gas came on line. Here also it was possible to simplify the scheme for controlling the field and introducing certain industrial adjustments. By reducing the amount of metal used in equipment about 2 million rubles of capital outlay could be saved.

In 1979, on the threshold of the 62nd anniversary of Great October, a third field (UKPG-3) was set up at Urengoy. Since the beginning of operation in this field 30 billion m^3 of gas have been obtained. This has taken only 1 and 1/2 years, and the gas was supplied to the new high-output transporting system--the first phase of the Urengoy-Surgut-Chelyabinsk pipeline. This has allowed the Tyumen' TETs to switch over to gas.

The on-going creative search in addition to consideration of the earlier accumulated experience has enabled Urengoy to apply a number of innovations. Multiple drilling of boreholes is practiced here. The traditional radial scheme of gas gathering has been replaced by the collector scheme, which has permitted an approximately one-fifth reduction in the length of the field pipelines. For the project "Urengoy-30" increased pressure is used, regeneration of the diethyleneglycol is improved, and a number of pumps have been added. In this way the output of the units has increased from 7 to 10 billion m^3 per year; productivity has increased by 30 percent. Glycol regeneration has changed in principle. The principle of steam regeneration is used in the first four fields, but experimental firing using modern Soviet equipment developed by Minkhimnash [Ministry of Chemical and Petroleum Machine Construction] will be installed in the fifth one.

The industrial method is used as a basis for management of Urengoy field. Practically all auxiliary facilities have been made in box units. All structures--from complex technological installations to public buildings and warehouses--have been unitized. A gas-turbine electric power station in a unit-complex design with an output of 72kW has been used for the first time in practice by Mingazprom for the energy needs of the field.

All operating wells at Urengoy have been equipped with modern gusher fittings. Well construction includes an 8-inch column and special bottom equipment, which assures a maximum weight of gas extraction with a minimum of field expenditures in structures. Upon the suggestion of the inventors V. S. Zakharenkov, B. S. Akhmetshin, G. L. Krivosheyev and V. L. Slivnev the operations for opening up, operating and exhausting the well for the projected technological regime have been combined into a single cycle, which has made it possible to shorten the idle time of wells following their opening up after drilling and to save about 6 million m^3 of gas for each pocket of wells.

At present the unit-complex technological lines of installations for complex preparation of gas are being put into operation completely automated, while the start-up operations according to the basic technology automation are being assembled. V. S. Vitkov, director of production automation service, M. A. Balavin, foreman, and V. I. Yefimov, fitter, have proposed and assimilated this advanced method.

The Urengoy inventors, together with specialists of a number of scientific research institutes of the industry, have done important work in investigating and optimizing the technological regime of fields. Increased values of gas in a field are assured not only because of the new capacities, but also because of the rational exploitation.

Many leading planning and scientific research institutes are concerned with the problem of developing the Urengoy gas-condensate field. Scientists of Tyumenniigiprogaz suggested the interesting complex project of opening up the field. It gave special attention to the problems of providing increased reliability and effective development, overall and more complete extraction of gas and associated components. It is hoped to bring the annual recovery of gas from the Senoman Strata to 160 billion m^3. In addition, it is hoped to annually produce about 25 billion m^3 of gas from Valangin beds and a significant amount of condensate, for which 634 wells must be drilled. In order to exploit the Valangin stratum five fields must be constructed with the suggested combination of gas and condensate extraction. It is planned to construct a gas processing plant in the area of the operating second field, which will annually supply different brands of fuel.

In a speech at the November (1979) Plenum of the CPSU Central Committee, Comrade L. I. Brezhnev called for an increase in the rates of gas recovery, along with its effective utilization. One hundred forty-eight billion m^3 of gas have yet to be recovered. Urengoy will contribute 37 billion m^3 of this increase.

A collective, capable of solving the most complex problems, has been formed at Urengoygazdobycha association. A majority of the workers have gone through the difficult school of Pungi, Pokhromy, and Medvezh'ye fields. They include winners of the decoration Red Banner of Labor, operators V.S. Zakharenkov and G. P. Chernova; winners of the decoration "Badge of Honor" fitter G. L. Krivosheyev and of the decoration Glory of Labor of the third degree, fitter V. P. Nobikov and the driller A. S. Kolov. The director of Urengoygazdobycha association I. S. Nikonenko, winner of the State Prize in the area of science and technology, was awarded the Order of Lenin. The collective of the association twice won the outstanding Red Banner of Mingazprom and of the Central Committee of the industry trade union, and the gas field workers of the second field were awarded with the Red Banner VLKSM [All-Union Lenin Young Communist League] Central Committee "veterans of labor, heroes of the five-year plan--the best komsomol-youth collective." They were also awarded the prize of the magazine "Smena" and the pennant of the VLKSM Central Committee for opening up the petroleum and gas fields in Western Siberia.

Urengoy is increasing its rate of growth, and its conquerors are doing everything possible so that the country can produce as much gas as possible from here on out.

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FUELS

REDUCING LOSSES OF GAS, CONDENSATE BY TURKMENGAZPROM

Moscow GAZOVAYA PROMYSHLENNOST'. SERIYA: EKONOMIKA GAZOVOY PROMYSHLENNOSTI. (REFERENTIVNAYA INFORMATSIYA) in Russian No 11, 1979 pp 18-21

[Article by M. Mamedov, Turkmengazprom (Turkmen Gas Industry): "Ways of Reducing Technological Losses of Gas and Condensate in Enterprises of Turkmengazprom"]

[Text] Being guided by directives of the 25th CPSU Congress and by instructions of the November (1978) Plenum of the CPSU Central Committee, Turkmengazprom [Turkmen Gas Industry] in addition to increasing the amount of gas produced has been conducting a full scale project to reduce the technological losses of gas and condensate (see table).

Dynamics of Gas and Condensate Utilization for Our Own Needs

Expenditure	1975	1976		1977		1978	
	actual	planned	actual	planned	actual	planned	actual
Gas (including losses) % of amount recovered	0.86	0.70	0.61	0.74	0.69	0.71	0.67
Thousands of tons	17.4	19	21	14	14.5	19	19.7

Gas is used by the association for its own needs:

as fuel for the gas turbines of the DKS (construction workers' houses of culture) at the Achak, Naip and Gugurtli deposits and for the gas air conditioning unit in the main buildings of the Achak deposit;

as fuel for heating boilers for the everyday needs of the enterprises;

for pre-heating firing evaporators of the diesel electric regenerating units;

for "cleansing" during scheduled preventive maintenance repairs of the technological devices in supply lines;

for cleaning boreholes during their utilization;

during condensate degasification.

In this case about 80 percent of the gas used for our own needs is used as fuel for the gas turbines. A certain increase in gas consumption for our own needs in 1977 and 1978, in comparison with the date for 1976, is due to the introduction of DKS at Naip and Gugurtli deposits, whose units have a gas turbine drive. However, this is significantly lower than the 1975 level.

For 1979, in spite of the increased demands for gas extraction, its planned expenditure for our own needs has been reduced to 0.65 percent of the extracted volume.

A gas savings has been achieved in 1975-1978 by virtue of:

strict regulation of gas consumption for our own needs;

a scientifically based standard gas consumption for our own needs and losses;

a reduction in the amount of time used to purge boreholes by 4 hours during utilization;

the use of ejectors at the Shatlyk and Gugurtli deposits for utilization of low pressure gases;

use of the "Condensate--2" device which permits one to determine the technical condition of separators and to reveal technological devices which are defective and undergoing alteration without stopping them.

Gas condensate which is used at the association basically is used as the solvent for a corrosion inhibitor for injection into boreholes at Shatlyk, Bayram-Ali, Kirpichli, Mayskoye and Tedzhen deposits. The necessary amount of condensate for inhibiting boreholes is computed in conformity with recommendations of Sevkavniigaz, which is entrusted with supervision of measures for controlling corrosion at the deposits of the association.

As was noted, about 80 percent of the gas used for our own needs is consumed as fuel by gas-driven compressors. Therefore, one of the main sources for reducing gas consumption is the application of more economical GPA. Decentralization of association enterprises over a large area, and the remoteness from gas consuming regions, necessitates acceleration of adoption of economical GPA by Soviet industry. In the future, along with a reduction of seam pressures at Shatlyk, Bayram-Ali and Kirpichli deposits, the association's need for GPA will double.

Improved technological systems for collecting and preparing gas and gas condensate are needed. The systems of commercial preparation of gas, which are used at the present time, do not assure complete utilization of low pressure gas from separation units and condensate stabilization units. Single-stage high-speed ejectors which are proposed in the new plans will permit one to return only a portion of the degasified gases into the system. Because of complexity in designing and selecting ejector nozzles, they cannot be applied in all enterprises.

And there are other problems whose solution will allow one to significantly increase the efficiency of gas utilization and to lower its technological losses:

faster production of remotely controlled valves for flow fittings;

development of cut-off valves with improved design;

accelerated development of designs of underground equipment complexes for boreholes with high gas temperatures (above 100°C) and which contain aggressive admixtures.

The low temperature method of gas separation in a number of cases does not assure complete condensation, in the technical devices, of heavy hydrocarbons (C_{5+}), which are contained in the extracted gas. A portion of the higher hydrocarbons is contained in the gas being transported in vapor phase state. Therefore, the principal means for increasing the degree of utilization of condensate in the enterprises is improvement in the technology of preparing gas at the gas-condensate deposit surface. During selection of a technological scheme for preparation of gas-condensate deposits by planning institutes, in addition to the parameters and indices currently being considered, attention must be paid to pressure of the maximum condensation of the C_{5+} which are contained in the gas and the optimum gas separation temperature at the NTS [Scientific Technical Council]. A pressure which is close to the pressure of maximum condensation of heavy hydrocarbons must be assured in the low-temperature separators.

In order to reduce technological losses of condensate in 1978, the following projects were carried out. The operation of technological equipment was systematically checked at enterprises in order to immediately detect any limited defects. In order to prevent entry of liquid into the gas supply line at the Naip UKPG-1 and UKPG-2 fields, which were formerly exploited by a decentralized scheme, these fields were switched to the main buildings; in these buildings an imported separation unit was installed as a third stage of separation, which allowed one to significantly improve quality of the gas which was fed into the gas supply line. At Shatlyk field shut-off fittings and valves for ejecting liquid were replaced; there was an inspection and repair of the low-temperature of the S-201 separators; the R-401 separators were inspected in order to prevent entry of condensate into the system of commercial stocks, and the R-402 separators were examined in order to avoid entry of condensate and water-condensate emulsion into the firing evaporators with saturated diesel-electric drive; studies were carried out by the "Condensate'2" device to determine the operating efficiency swirl cones of the S-101, S-102 and S-202 separators.

In addition there were problems of increasing the degree of utilization of condensate, which must be solved in the near future. Among these are the construction of a refrigeration unit at the Naip and Gugurtli fields and condensate stabilization units at the Naip field; the introduction of Ukrniigaz (expansion unknown) fluorplastic filters for gas separation at the Achak field; redesigning the absorbers at the main buildings of this field for the application of liquid separation by spherical nozzles designed by VNIIgaz (All Union Scientific Institute of Natural Gas); the use of surface active substance DS-RAS for breaking down the water-condensate emulsion in the main buildings of Shatlyk field. Measures to increase the effectiveness of utilization and the savings of gas were also noted:

maintain optimum loads of GPA at the Achak, Gugurtli and Naip DKS;

reduction of the number of gas purgings of inhibitor pipelines due to the use of compressed air;

the introduction of ejectors for utilization of low pressure gases at the Kirpichli and Shatlyk fields;

increase length of time between repairs for technological equipment.

Fulfilling these measures will permit the association to save no less than 12 million m^3 of natural gas in 1979.

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FUELS

NORMS FOR GETTING SUPPLIES TO TYUMEN' REPORTED

Moscow ORGANIZATSIYA I UPRAVLENIYE NEFTYANOY PROMYSHLENNOSTI in Russian No 4, Apr 80, pp 7-10

[Article by G.I. Vasina, Yu. K. Lobanov and N.A. Soshnikova of the All-Union Scientific Research Institute for the Organization of the Management and Economics of the Oil and Gas Industry (VNIIOENG), Moscow: "Specifics on the Standardization of Material Resource Seasonal Reserves Within Associations Under the Main Administration for Petroleum and Gas for the Tyumen' Region (Glavtyumenneftegaz)"]

[Text] The problem of fuel and power occupies one of the most important places among the basic industry inter-branch problems of our national economy. Western Siberia is of basic significance in its resolution.

An increase in the extraction of petroleum in the regions of Western Siberia requires constant improvement in the organization of material-technical supply and a scientifically based standardization of material production reserves.

Under the conditions which exist in Tyumen' Oblast of the Far North, we are speaking of seasonal reserves. The seasonal reserve, as is known, is put together under conditions in which it is impossible to make regular deliveries during the course of the year resulting in periodic interruption in the delivery of material-technical resources to the consumer.

Constituting the production reserve norm under the system of deliveries for an entire season is the minimal amount of material-technical resources in the hands of the consumer at the beginning of the year, an amount which will facilitate the uninterrupted production process.

The basic norm-setting factors used in the formation of a seasonal reserve consist of the following:

The average daily requirement for material-technical resources during the plan period;

The maximal length of the seasonal interruption in the delivery of these resources;

The length of the interruption in deliveries from 1 January to the latest possible date of delivery following completion of the seasonal interruption;

The time necessary to deliver to the consumer material-technical resources from bases of production-technical servicing and equipment supply (BPTOK).

Material-technical supplies to enterprises subordinate to the Main Administration from Petroleum and Gas for the Tyumen' Region are delivered, basically, during the period of navigation on the Ob' (The Irtysh Basin) and Konda rivers from the middle of May until the 3rd 10-day period in October. However, railroad transport is essential for enterprises of the main administration which are located along the central reaches of the River Ob' (the "Yuganskneftegaz" Association, the "Surgutneftegaz" Association, and the "Nizhnevartovskneftegaz" Association). Along the Tyumen'-Surgut railway, which has now been taken over for operation by the USSR Ministry of Railways, and along the Surgut-Nizhnevartovsk and Surgut-Urengoy roads which are still under construction, material-technical resources (MTR) from suppliers proceed to the BPTOK bases of production associations. Most of these resrouces, however, are delivered during the winter period and in the first and fourth quarters of the year, inasmuch as the railroads are loaded with the cargoes of other consumers during the second and third quarters of the year.

A characteristic peculiarity of the transportation of material-technical resources into the areas of Western Siberia is the availability of several consistent seasonal routes. Typical are the following diagrams for the delivery of material-technical resources (MTR) along routes which function with seasonal interruptions (see drawing on next page).

In the first two instances, a consumer has his material-technical resources delivered to him along one of the seasonal routes--along a winter road (1) or by water during the navigation period (2) and, in the one and the other instance, the BPTOK (railside base) receives its resources regularly during the course of the year.

Of greatest complexity is the calculation of norms for situations 3 and 4 of the diagram on deliveries, when the consumer has his material-technical resources (MTR) hauled in along two consistant seasonal routes through a transshipment base (BPTOK).

Supplier
via railroad
BPTOK base of association
via winter road
Production installation

(1)

Supplier
via railroad
BPTOK base of association
via river
Production installation

(2)

Supplier
via river
BPTOK base of association
via winter road
Production installation

(3)

Supplier
via river
BPTOK base of association
via river
Production installation

(4)

Diagram of the Delivery of Material-Technical Resources Along Routes Functioning with Seasonal Interruptions

We will examine how seasonal reserve norms are set for associations under Glavtyumenneftegaz by using an example in which the norms for reserves of casing pipe for the "Nizhnevartovskneftegaz" Association are determined.

The initial information for our calculations consists of the following:

A list of production installations (sites);

A list of railside and transshipment bases;

Characteristics of the route for the delivery of material-technical resources (MTR);

Functioning parameters of the routes, namely:

A) The dates of the beginning and end of operations on a particular route (using the very latest and the earliest dates for the opening and close of navigation over a period of several years);

B) Length of operation of the route;

C) Time spent by the material-technical resources en route, this established on the basis of the average speed of movement of the means of transport and the distance covered.

The yearly requirement for material-technical resources (MTR).

The initial information is presented in Table 1.

On the basis of the Table 1 initial data, we calculate the length of the seasonal interruption for every site in the Nizhnevartovskiy Rayon.

For such sites as the Samotlorskoye, Mykhpayskoye, Aganskoye, Vatinskoye and Megionskoye, it is possible to deliver material-technical resources all year round. The duration of the seasonal interruption for this group of sites depends only on the length of the navigational period. This we can figure out on the basis of the following formula:

$$T_{сез} = K_{он} + t, \qquad (1)$$

in which $T_{сез}$ — is the duration of the seasonal interruption, in days;

$K_{он}$ — is the date of the beginning of navigation, from 1 January;

t — is the time spent by the material-technical resources en route, in days.

The duration of the seasonal interruption, figured on the basis of this formula, for these particular sites is 137 days.

At the Nong-Yeganskoye, Severo-Pokurskoye, Potochnoye, Ur'yevskoye, Povkhovskoye, Khokhryakovskoye, Permyakovskoye, Yermakovskoye, Orekhovskoye, Vyngapurskoye, Novogodneye, Severo-Khokhryakovskoye sites, it is possible to haul material-technical resources (MTR) to them only in the winter time and on temporary roads (winter roads). Consequently, the duration of the seasonal interruption for this group of sites depends on the beginning of operation of the winter road and is figured on the basis of the following formula:

$$T_{сез} = K_{з.н} + t, \qquad (2)$$

in which $K_{з.н}$ — is the date of beginning of operations on the winter road, from 1 January.

The duration of the seasonal interruption is equal to 352 days.

Table 1 "Nizhnevartovskneftegaz" Association

Sites	Ports from which cargoes are shipped	Production-technical servicing and equipment supply base (BPTOK)	Rivers along which cargoes travel	Start of navigation time: At loading points	Start of navigation time: At unloading points	Distance along stream from departure point to unloading point (at bases)	Average speed of loaded vessels km/day: Upstream	Average speed of loaded vessels km/day: Downstream	Time spent by ships from point of departure to point of unloading (in days)	Time for ship handling (in days)	Availability of year-round roads, base to site	Time for delivery of cargoes from base to site, including time for loading-unloading OP's	Winter road functioning period: Beginning	Winter road functioning period: End	Length of seasonal interruption (in days)
Samotlorskoye, Mykhpayskoye, Aganskoye, Vatinskoye, Megnonskoye,	Tyumen', Omsk, Tobolsk	Nizhnevartovskaya BPTOK	⁻Ob'	10/V	11/V	1759	284	405	5	2	Yes	---	--	--	137
Nono-Yeganskoye, Sev. Pokurskoye, Potochnoye, Ur'Yevskoye, Povkhovskoye, Khokhryakovskoye, Permyakovskoye, Yermakovskoye-orekhovskoye, Vyngapurskoye, Novogodneye, Sev. Khokhrya-kovskoye	Tyumen', Omsk, Tobolsk	Nizhnevartovskaya BPTOK	⁻Ob'	10/V	11/V	1759	284	405	5	2	No	2	15/XII	15/IV	352
Tagrinskoye, Sev. Var'Yegan-skoye, Var'Yegankoye, Van-Yeganskoye, Tyumenskoye, Pokachevskoye	Tyumen', Omsk, Tobolsk	Nizhnevartovskaya BPTOK,	⁻Ob'	10/V	11/V	1759	284	405	5	2	No	2	15/XII		352
			Ob'	10/V	11/V	1759	284	405	5	2	No	1		15/IV	321
		Novo-aganskaya BPTOK	Agan		3/VI	--	---	---	1	1	Yes		--	--	158

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On the basis of the factual structure of deliveries and the data of the analysis of hauling in and hauling out casing pipe at association bases at Tagrinskoye, Severo-Var'yeganskoye, Var'yeganskoye, Van-Yeganskoye, Tyumenskoye and Pokachevskoye, a system of combined hauling of material-technical resources has been adopted. The duration of the seasonal interruption for these sites is presented in Table 1.

On the basis of data as to yearly casing pipe required for every association site, as well as the calculated duration of the seasonal interruption, we can determine the seasonal reserve norm for casing pipe for the association as a whole without figuring in the work of railroads.

Considering the fact that part of the casing pipe, namely 40 percent of the yearly requirement, is hauled by railroads to bases of the association, we make a correction to the seasonal reserve norm. In making this correction, we accept the fact that 20 percent of the annual requirement for casing pipe is hauled into bases of the association via railroad in the first quarter and that 20 percent is delivered in the fourth quarter, with 60 percent delivered during the navigation period (30 percent each in the second and third quarters). In keeping with this, norms take on the following significance:

A) For casing pipe arriving at bases regularly: 46 days for sites which have year-round roads operating out to them; 244 and 198 days (depending upon how long winter roads are in operation) for sites receiving their casing pipe along winter roads.

B) For casing pipe arriving at bases during the navigation period: 137 and 158 days (depending upon the length of the navigation period) for sites which have year-round roads operating out to them; 321 and 352 days (depending upon the length of operation of winter roads) for sites which receive their pipe only through winter roads.

The corrected seasonal reserve norms for casing pipe for the "Nizhnevartovskneftegaz" Association for 1980 comes to 209 days, or 143,000 tons.

By analogy, we can determine the norms for all oil extraction regions of Glavtyumenneftegaz as to the basic types of material-technical resources (Table 2).

Table 2

Material-technical resources	Seasonal reserve norms for Glavtyumenneftegaz for 1980 (in days)	By various associations			
		"Nizhnevartovskneftegaz"	"Surgutneftegaz"	"Yuganskneftegaz"	"Urayneftegaz"
Casing pipe	205	209	208	175	352
Drill pipe	204	206	209	174	352
Seamless pipeline pipe	203	207	208	176	352
Electrically welded pipeline pipe	204	207	209	175	352
Pump-compressor pipe	204	207	207	175	352
Rolled ferrous metal products	204	207	209	175	352
Tamponage cement	203	208	201	173	352
Fuel	153	139	146	124	352
gasoline	141	126	138	114	352

These norms serve as the foundation for the material-technical supply plan for Glavtyumenneftegaz for 1980, which will facilitate an increased effectiveness in the work of the main administration's oil-extraction associations.

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END